



Ontario

Ministry of
Northern Development
and Mines

**Ontario Geological Survey
Open File Report 5586**

**Geology of Chabanel,
Esquega, Lastheels and
McMurray Townships,
District of Algoma**

1993



Ontario

Ministry of
Northern Development
and Mines

102-06858/

ONTARIO GEOLOGICAL SURVEY

Open File Report 5586

Geology of Chabanel, Esquega, Lastheels and McMurray Townships,
District of Algoma

By

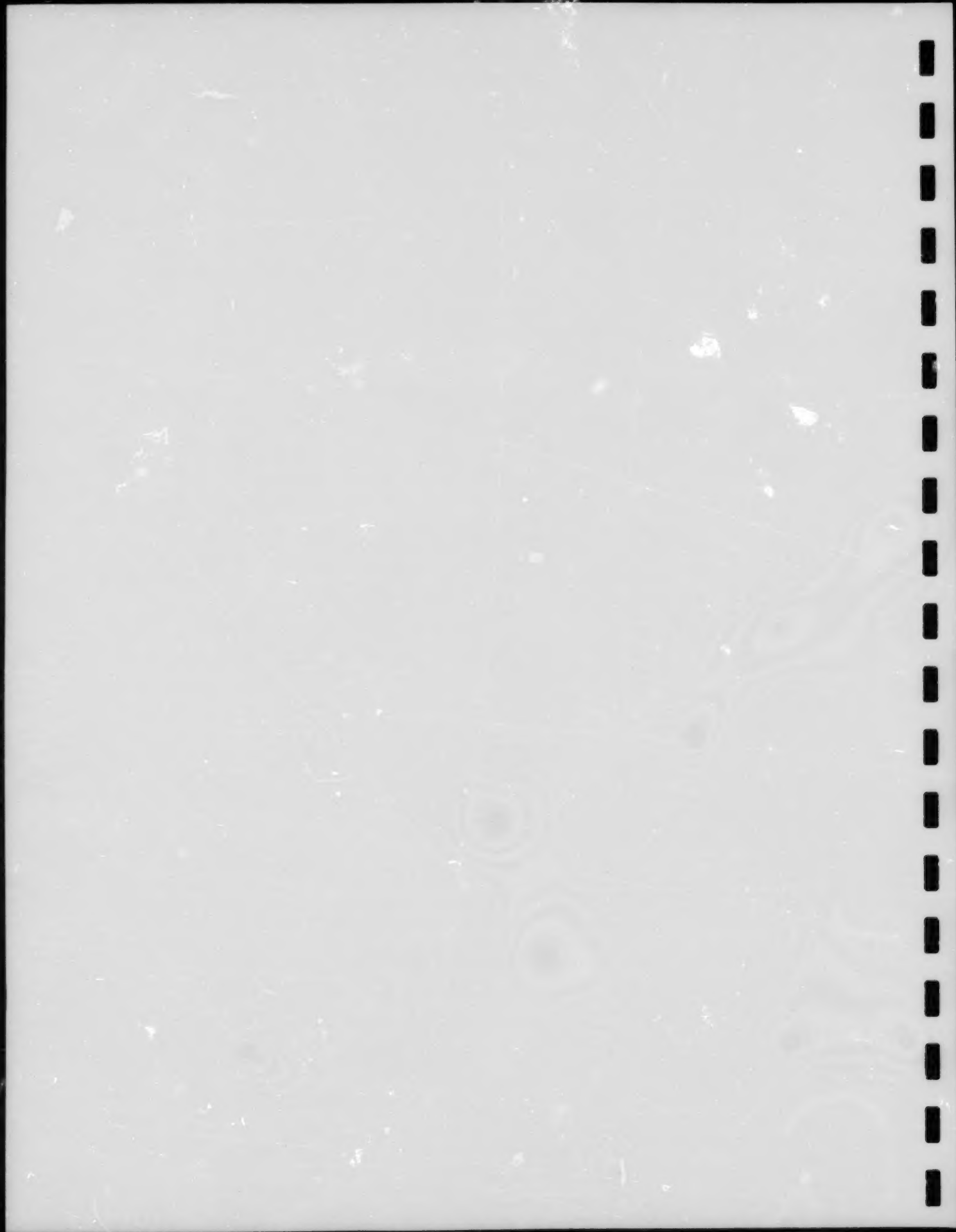
R. P. Sage

1993

Parts of this publication may be quoted if credit is given. It is recommended that reference to this publication be made in the following form:

Sage, R. P. 1993. Geology of Chabanel, Esquega, Lastheels and McMurray townships, District of Algoma; Ontario Geological Survey, Open File Report 5586, 462p.

© Queen's Printer for Ontario, 1993



Ontario Geological Survey

OPEN FILE REPORT

Open File Reports are made available to the public subject to the following conditions:

This report is unedited. Discrepancies may occur for which the Ontario Geological Survey does not assume liability. Recommendations and statements of opinions expressed are those of the author or authors and are not to be construed as statements of government policy.

This Open File Report is available for viewing at the following locations:

Mines Library
Level A3, 933 Ramsey Lake Road
Sudbury, Ontario P3E 6B5

Mines and Minerals Information Centre (MMIC)
Rm. M2-17, Macdonald Block
900 Bay St.
Toronto, Ontario M7A 1C3

The office of the Resident Geologist whose district includes the area covered by this report.

Copies of this report may be obtained at the user's expense from:

OGS On-Demand Publications
Level B4, 933 Ramsey Lake Road
Sudbury, Ontario P3E 6B5
Tel. (705) 670-5691 Collect calls accepted.

Handwritten notes and sketches may be made from this report. Check with MMIC, the Mines Library or the Resident Geologist's office whether there is a copy of this report that may be borrowed. A copy of this report is available for Inter-Library loan.

This report is available for viewing at the following Resident Geologists' offices:

Wawa, Box 530, Helen Mine Rd., Wawa P0S 1K0

The right to reproduce this report is reserved by the Ontario Ministry of Northern Development and Mines. Permission for other reproductions must be obtained in writing from the Director, Ontario Geological Survey - Geoscience Branch.

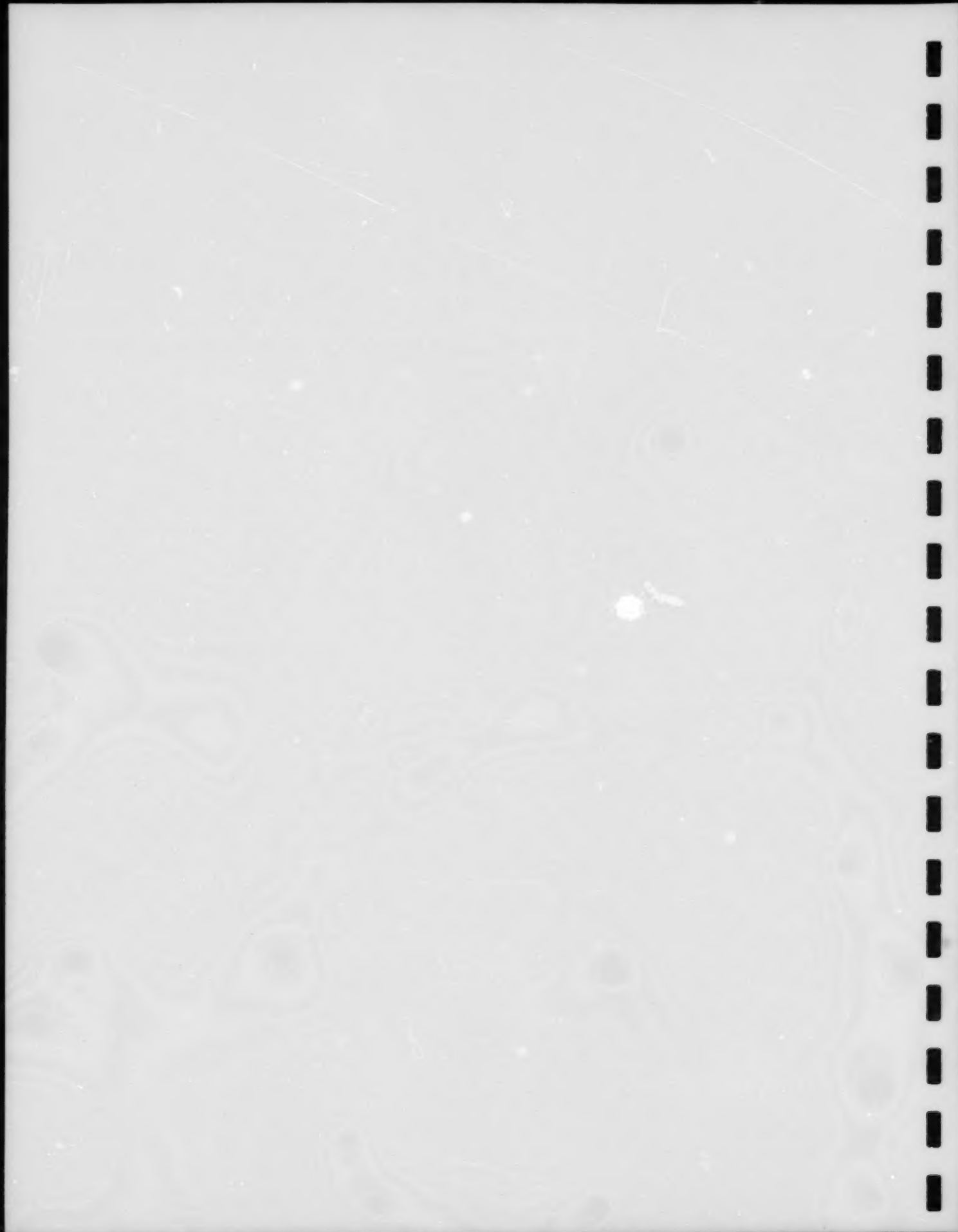
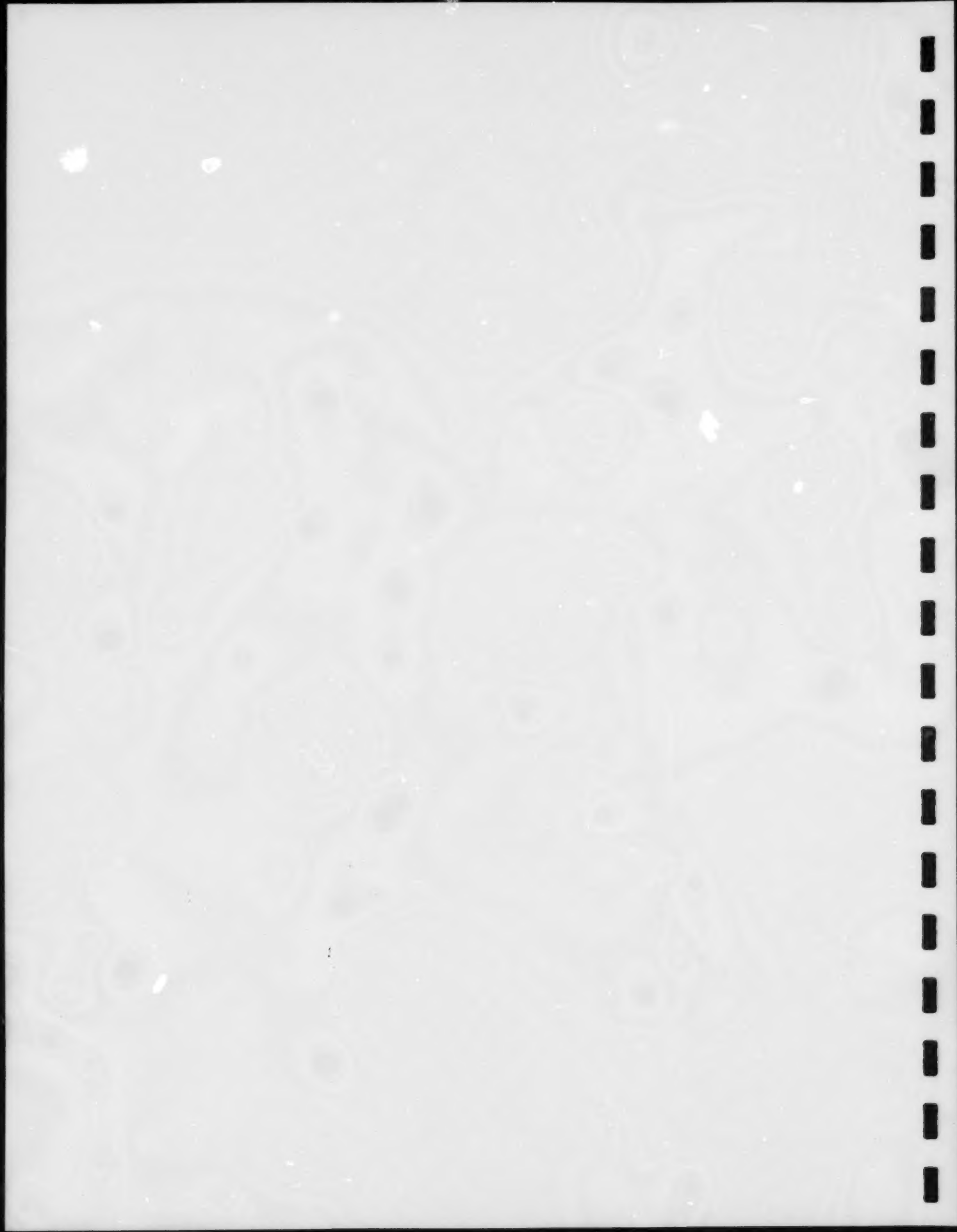


TABLE OF CONTENTS

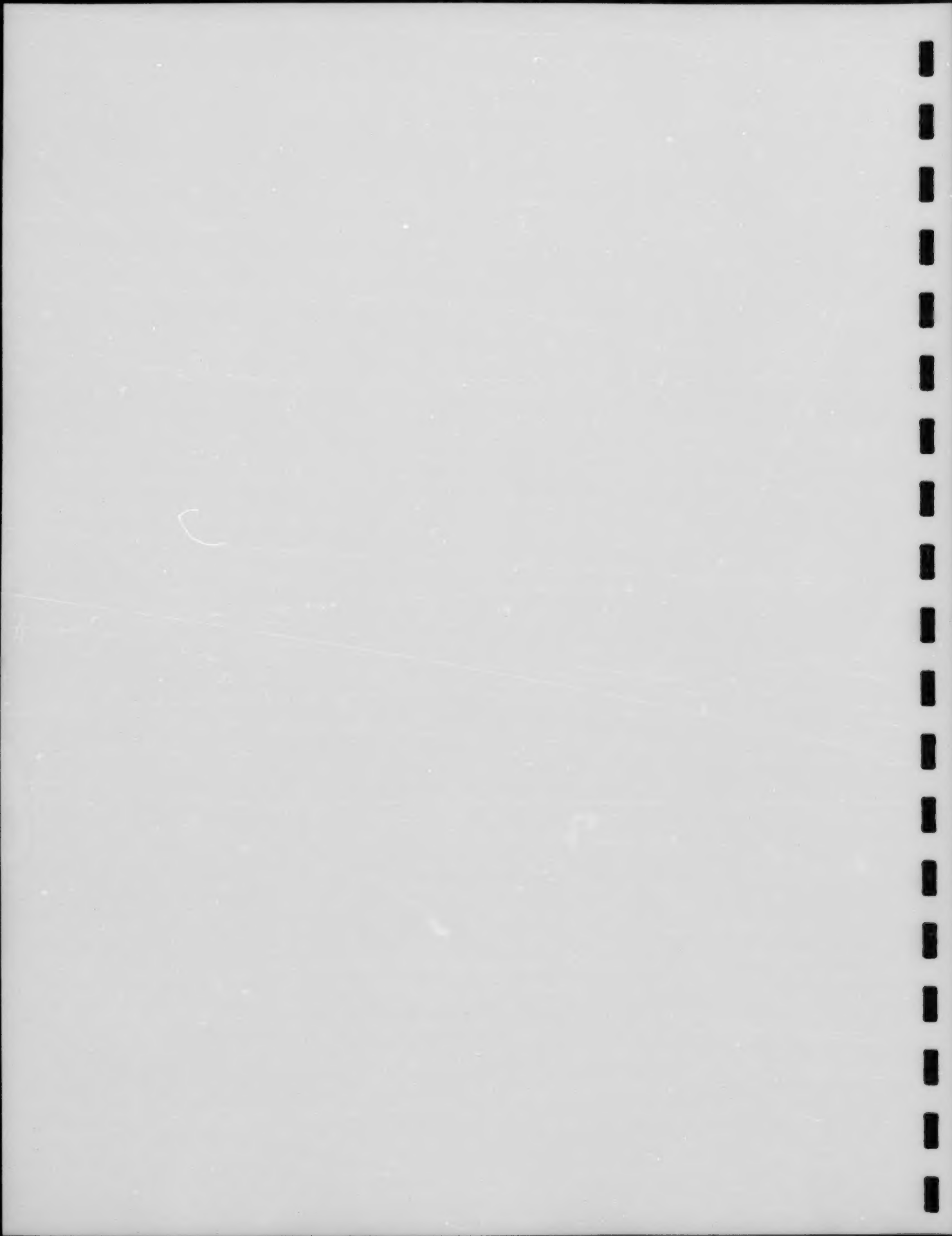
Abstract.....	XLI
Introduction.....	1
Acknowledgements.....	1
Location and Access.....	2
Physiography.....	3
Field Procedures.....	3
Previous Work.....	4
General Geology.....	5
External Granitic Rocks (Map Unit 1).....	9
Hawk Lake Migmatite Complex.....	9
Whitefish Lake Batholith.....	12
Intermediate to Mafic Metavolcanic rocks (Map Unit 2).....	13
Subcycle 1 Intermediate to Mafic Metavolcanic rocks.....	13
Cycle 1 Intermediate to Mafic Metavolcanic rocks.....	14
Cycle 2 Intermediate to Mafic Metavolcanic rocks.....	17
Cycle 3 Intermediate to Mafic Metavolcanic rocks.....	17
Intermediate to Felsic Metavolcanic rocks (Map Unit 3).....	18
Subcycle 1 Intermediate to Felsic Metavolcanic rocks.....	18
Jubilee Tuffs.....	20
Intermediate to Felsic Metavolcanic rocks (Cycle 1).....	24
Coarse Breccia.....	25
Ash Flow Breccias.....	26
Polymictic Breccias and Lapilli Tuffs.....	26
Tuff.....	28
Crystal Tuffs.....	29
Massive Flows.....	30
Spherulitic Flows.....	30
Miscellaneous Porphyritic Flows.....	32
Interpretation of the Stratigraphy of Cycle 1 Volcanism....	32
Interpretation of Goodwin and Shklanka (1967) and	
Goodwin (1962, 1964).....	33
Interpretation of Osterburg (1982).....	35
Interpretation of Nebel (1982), Morton and Nebel (1983)....	36
Cycle 2 Intermediate to Felsic Metavolcanic rocks.....	38
Tuff, Laminated Tuff.....	39
Quartz-Feldspar Crystal Tuff.....	39
Lapilli Tuffs.....	40
Breccia.....	40
Metasedimentary rocks (Map Unit 4).....	43
Ferruginous Dolomite.....	59
Iron Formation (Map Unit 5).....	60
Carbonate Facies.....	61
Sulphide Facies.....	64
Chert-Magnetite-Wacke Facies.....	67
Chert-Wacke Facies.....	68
Argillite-Pyrite-Graphite Facies.....	69



Brecciated Iron Formation.....	70
Iron Formation-Quartz Veining.....	71
Iron Formation-Weathering.....	73
Iron Formation-Isotopes.....	75
Oxygen.....	76
Sulphur.....	76
Carbon.....	78
Iron Formation - Geochemistry.....	79
Organic Chemistry.....	79
Inorganic Chemistry.....	79
Arsenic.....	81
Gold.....	81
Boron.....	81
Barium.....	82
Bismuth.....	82
Cerium.....	82
Cobalt.....	83
Chromium.....	83
Copper.....	83
Gallium.....	83
Lithium.....	84
Niobium.....	84
Nickel.....	84
Manganese.....	84
Lead.....	84
Antimony.....	85
Scandium.....	85
Selenium.....	85
Tin.....	85
Strontium.....	85
Vanadium.....	86
Yttrium.....	86
Zinc.....	86
Zirconium.....	86
Minor Element Chemistry - Summary.....	87
Michipicoten Type Iron Formation -	
Environment of Deposition.....	88
Origin.....	92
Chronological Historical Review.....	92
Michipicoten Iron Formation Origin - Summary.....	102
Mafic Intrusive Rocks (Map Unit 6).....	104
Mafic Intrusions in Cycle 1 Intermediate to Mafic	
Metavolcanic rocks.....	104
Mafic Intrusions Within the Footwall of the	
Michipicoten Iron Ranges.....	104
Reed Lake Mafic Stock.....	107
Old Diabase.....	108
Sunrise Lake Mafic to Ultramafic Intrusion.....	109
Late Peridotite-Pyroxenites.....	111
Felsic Intrusive Rocks (Map Unit 7).....	113



Hawk Lake Granitic Complex.....	113
Quartz - Feldspar Porphyries.....	114
Jubilee Granitic Stock.....	117
Firesand River Carbonatite (Map Unit 11).....	118
Proterozoic Diabase Dikes and Lamprophyres (Map Unit 12).....	119
Diabase Dikes.....	119
Normal Diabase.....	121
Quartz Diabase.....	121
Olivine Diabase.....	121
Lamprophyres.....	122
Cenozoic.....	125
Metamorphism and Alteration.....	128
Chloritoid Alteration - Intermediate to Mafic Metavolcanic rocks.....	136
Chloritoid Alteration - Intermediate to Felsic Metavolcanic rocks.....	137
Chloritoid - Historical Background.....	137
Silicification - Intermediate to Mafic Metavolcanic rocks.....	139
Intermediate to Mafic Metavolcanic rocks - Geochemistry of Chloritoid Alteration.....	139
Intermediate to Felsic Metavolcanic rocks - Geochemistry of Chloritoid Alteration.....	142
Least Altered (Greenschist) Assemblage.....	149
Sericitic Alteration Assemblage.....	149
Chlorite Alteration Assemblage.....	150
Chloritoid Alteration Assemblage.....	151
Ankerite Alteration Assemblage.....	152
Discussion.....	152
Alteration - Summary.....	153
Structural Geology.....	155
Jubilee Granitic Stock.....	155
Hawk Lake Granitic Complex.....	156
Reverse Faulting.....	157
Strike Slip Faulting.....	159
Wawa Lake Fault.....	159
Hawk Lake Fault.....	161
Talbot Lake Fault.....	161
Helen Iron Formation.....	162
Magpie River Fault.....	165
Johnson Iron Range Fault.....	167
Loonskin Lake Fault.....	167
Transverse Faults.....	168
Firesand River Fault.....	168
Parkhill Fault.....	169
Wallbank Lake Fault.....	169
Mildred Lake Fault.....	170
Bauldry Lake Fault.....	171
Goetz Lake Fault.....	171
Marsden Fault.....	172
Folding.....	173



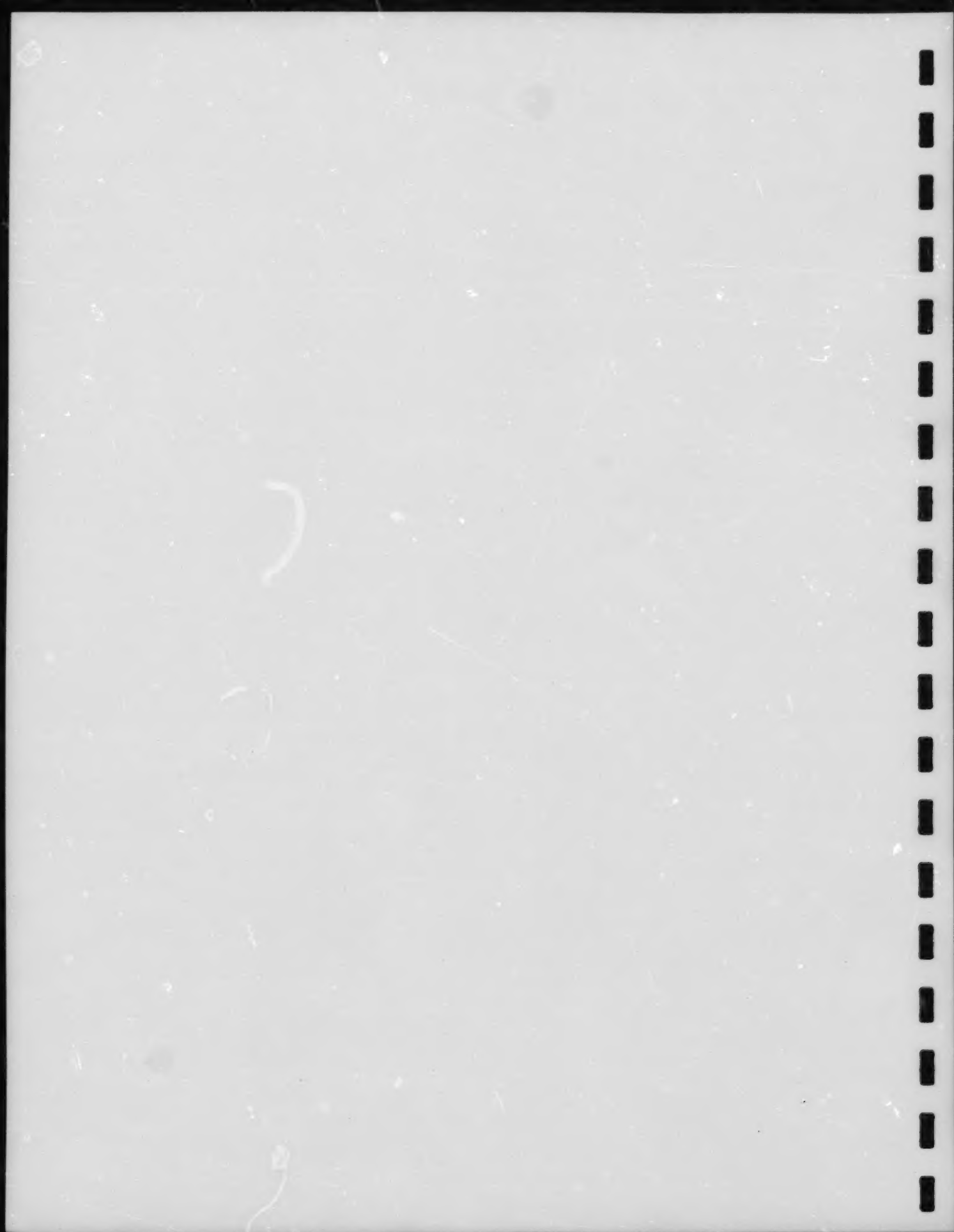
South Range Syncline.....	173
Centre Anticline.....	174
Kabenung - Josephine Cross Fold.....	174
Dore Cross Fold.....	174
Catfish Lake Anticline.....	175
Legarde Lake Anticline.....	175
Minor Folds.....	176
Deformation of Iron Formation.....	176
Tectonic Model.....	177
Petrology.....	180
Stratigraphy.....	182
Correlation Techniques.....	186
Economic Geology.....	189
Base Metals.....	189
Iron Deposits.....	189
Gold.....	191
Rare Earth Elements.....	196
Analogy Between Massive Base Metal Sulphide Deposits and Michipicoten Iron Formation.....	196
Recommendations for Prospectors.....	204
Iron Deposits.....	204
Gold Deposits.....	205
Base Metals.....	210
Rare Metals.....	211
REFERENCES.....	212

List of Tables

Table 1. Table of Lithologic Units for the Michipicoten Supra- crustal Belt, Wawa, Ontario.....	229
Table 3. Sample descriptions of analyzed iron formation samples used in composite section of Michipicoten iron formation (sample interval 1.3 m).....	232
Table 4. Minor element chemistry of iron formation samples used in composite section of Michipicoten Iron Formation.....	237
Table 5. Gold and boron contents within cycle two intermediate to mafic metavolcanic rocks.....	245
Table 6. Tabulated data for radioactive carbonatite dikes along Highway 101.....	246
Table 7. Mineral chemistry of chloritoid-bearing intermediate to mafic flows below Josephine Iron Range (Lockwood 1983, p.66-75) ..	247
Table 8. Major, Minor and Trace elements of the Lucy Meta- volcanic footwall rock (LeSeelleur 1980).....	256
Table 9. Calculation of water-rock ratios based on solubilities (LeSeelleur 1980).....	259
Table 10. Abundances of major, minor, and trace elements for the Helen footwall metavolcanic rocks (McMillan 1981, p.24). All	



samples prefixed with W108 to be keyed into Wawa sampling lists..	260
Table 11. Iron ore production and reserves Wawa, Ontario.....	262
Table 12. Tabulated surface diamond drilling for the Eleanor Iron Range.....	263
Table 13. Tabulated surface diamond drilling for the Helen Iron Range.....	264
Table 14. Tabulated assay data on siderite intersections from deep drilling on Johnson Iron Range.....	265
Table 15. Tabulated estimates of Open pit ore in place, for Ruth and Lucy Iron Ranges (Jarvis 1966).....	266
Table 16. Tabulated surface diamond drilling for Lucy Iron Range..	267
Table 17. Tabulated assay results from plan map of Regnery Mines Limited.....	268
Table 18. Tabulated assay data resulting from work completed by Canabec Explorations Incorporated.....	269
Table 19. Tabulated assay data on grab samples from the Mammoth Metals property (assays by Geoscience Laboratories, Ontario Geological Survey).....	270
Table 20. Tabulated assay values on grab samples from the Atnel Number 3 Vein.....	271
Table 21. Tabulated assay data on grab samples from the J. Bukell Copper Showing.....	273
Table 22. Tabulated assay data from Number 1 Vein. Firespur Explorations Limited Property, Channel samples reported by Allen (1928).....	274
Table 23. Tabulated surface diamond drilling for the Sunrise Lake Peridotite, Firespur Explorations Limited.....	275
Table 24. Tabulated grade and tonage estimates for the Sunrise Lake Peridotite as calculated by various authors.....	276
Table 25. Tabulated assay data on grab samples from the Murray Algoma Mining Company Limited Gold Occurrence.....	278
Table 26. Tabulated assay results from diamond drilling reported by Murray Algoma Mining Company Limited (AFRO, Toronto).....	279
Table 27. Tabulated diamond drilling for Ruth Iron Range.....	280
Table 28. Tabulated assay data on grab samples from the Soocana Reed-Booth Gold Occurrence.....	281
Table 29. Summary table of drilling results, Amax Minerals Exploration Limited (Yule 1980).....	282
Table 30. Tabulated surface diamond drilling for Citadel Mines Property.....	282
Table 31. Gold production from Minto Mine by levels (Rupert 1979).....	283
Table 32. Gold production from the Darwin or Grace Mine (Rupert 1976).....	283
Table 33. Tabulated diamond drill hole and assay data for Dunraine Mines Limited.....	284
Data Diskette: 5.25 inch high-density diskette containing MS-Word Geochemical data files.....	Back pocket



List of Figures

Figure 1. Location map for Chabanel, Esquega, Lastheels, and McMurray Townships, District of Algoma.....	4
Figure 2. Schematic diagram of lithologic relations, Michipicoten Supracrustal sequence.....	Back pocket
Figure 3. AFM (Irvine and Baragar 1971) plot of external granitic rocks.....	285
Figure 4. Jensen (1976) cation plot of external granitic rocks...	286
Figure 5. Streckeisen (1976) plot of norms of the external granitic rocks.....	287
Figure 6. Jensen (1976) cation plot of First Cycle intermediate to mafic metavolcanic rocks.....	288
Figure 7. AFM (Irvine and Baragar 1971) plot of First Cycle intermediate to mafic metavolcanic rocks.....	289
Figure 8. AFM (Irvine and Baragar 1971) plot of intermediate to mafic metavolcanic rocks of Lucy Iron Range Footwall rocks.....	290
Figure 9. Jensen (1976) cation Plot of intermediate to mafic metavolcanic rocks, Lucy Iron Range Footwall rock.....	291
Figure 10. Jensen (1976) cation plot for first cycle (dots) and second cycle (asterisk) intermediate to mafic metavolcanic rocks.....	292
Figure 11. A AFM (Irvine and Baragar 1971) plot of second cycle intermediate to mafic metavolcanic rocks above Lucy Iron Range...	293
Figure 12. AFM (Irvine and Baragar 1971) plot of second cycle intermediate to mafic metavolcanic rocks above Helen Iron Range..	294
Figure 13. Jensen (1976) Cation Plot for second cycle intermediate to mafic metavolcanic rocks above Lucy Iron Range.....	295
Figure 14. Jensen (1976) cation plot for second cycle intermediate to mafic metavolcanic rocks above Helen Iron Range.....	296
Figure 15. Jensen (1976) cation plot of all cycle two intermediate to mafic metavolcanic rocks.....	297
Figure 16. AFM (Irvine and Baragar 1971) plot of all cycle two intermediate to mafic metavolcanic rocks.....	298
Figure 17. AFM (Irvine and Baragar 1971) plot of subcycle one intermediate to felsic metavolcanic rocks.....	299
Figure 18. Jensen (1976) cation plot of subcycle one intermediate to felsic metavolcanic rocks.....	300
Figure 19. AFM (Irvine and Baragar 1971) plot of intermediate to felsic metavolcanic rocks, in Stanley Lake area and below Judith Iron Range.....	301
Figure 20. Jensen (1976) cation plot of intermediate to felsic metavolcanic rocks in the Stanley Lake area and below the Judith Iron Range.....	302
Figure 21. AFM (Irvine and Baragar 1971) plot of Jubilee feldspar - free tuffs.....	303
Figure 22. Jensen (1976) Cation Plot of Jubilee feldspar-free tuffs.....	304
Figure 23. AFM (Irvine and Baragar 1971) of Jubilee feldspar crystal tuffs.....	305

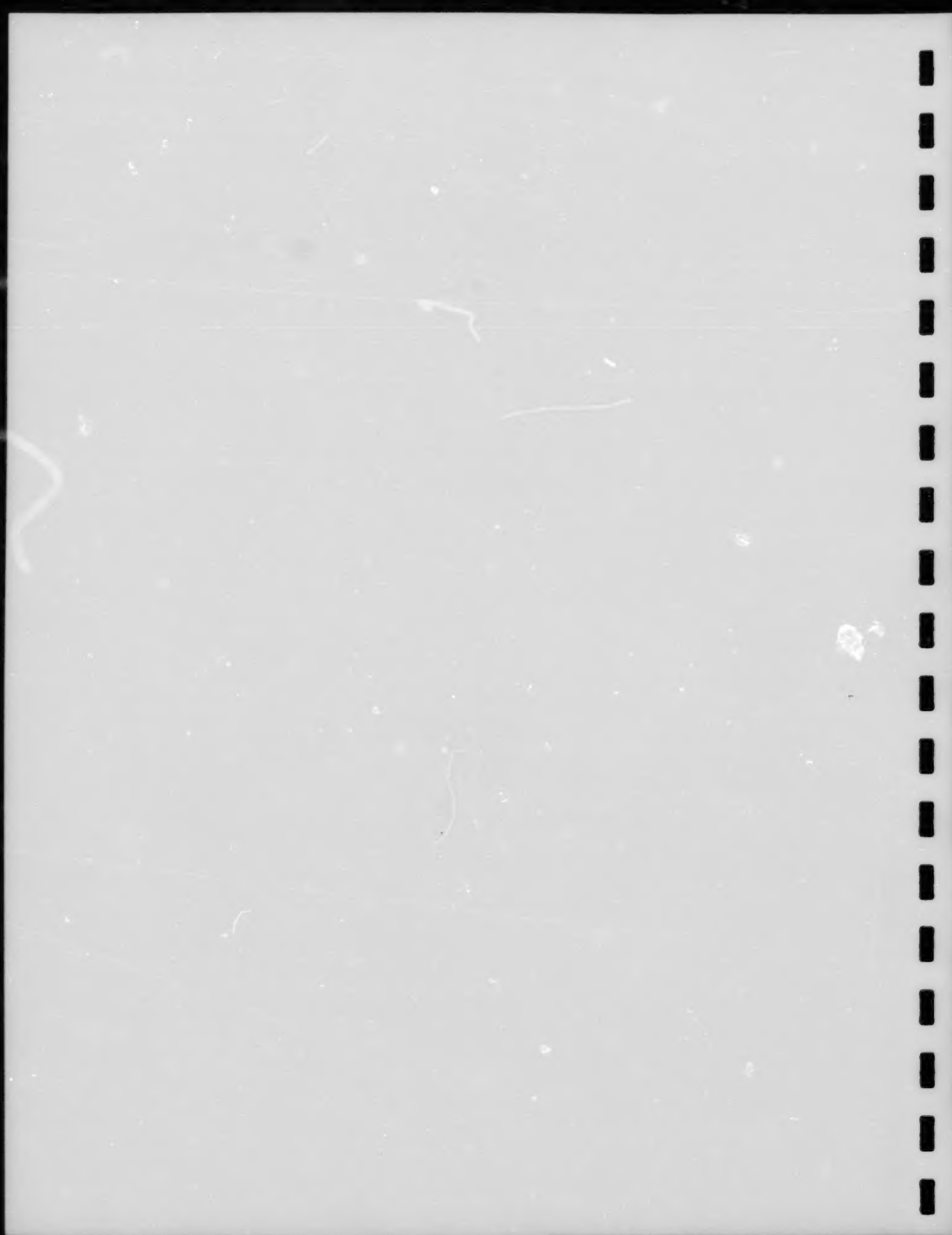


Figure 24. Jensen (1976) Cation plot of Jubilee feldspar crystal tuffs.....	306
Figure 25. Jensen (1976) Cation Plot of all Jubilee tuffs.....	307
Figure 26. AFM (Irvine and Baragar 1971) plot of all Jubilee tuffs.....	308
Figure 27. AFM (Irvine and Baragar 1971) diagram of intermediate to felsic metavolcanic rocks north of Wawa Lake.....	309
Figure 28. Jensen (1976) cation plot of intermediate to felsic metavolcanic rocks north of Wawa Lake.....	310
Figure 29. AFM (Irvine and Baragar 1971) plot of intermediate to felsic metavolcanic rocks south of Wawa Lake.....	311
Figure 30. Jensen (1976) cation plot of intermediate to felsic metavolcanic rocks south of Wawa Lake.....	312
Figure 31. Jensen (1976) cation plot of cycle two intermediate to felsic metavolcanic rocks.....	313
Figure 32. AFM (Irvine and Baragar 1971) plot of cycle two intermediate to felsic metavolcanic rocks.....	314
Figure 33. Generalized stratigraphic column north of the Magpie River, Chabanel Township (Modified after Foster 1981)....	Back pocket
Figure 34. Stratigraphic section in lower part of the Eleanor Slates (Modified after Neale 1981).....	Back pocket
Figure 35. AFM (Irvine and Baragar 1971) plot of Eleanor Slate metasediment samples.....	316
Figure 36. Jensen (1976) cation plot of Eleanor Slate meta- sediment samples.....	317
Figure 37. Stratigraphic section of metasedimentary rocks above Lucy Iron Range (Modified after Thomas 1984).....	Back pocket
Figure 38. Stratigraphic section and minor element variation in Michipicoten Iron Formation.....	Back pocket
Figure 39. AFM (Irvine and Baragar 1971) plot of miscellaneous mafic intrusive rocks.....	318
Figure 40. Jensen (1976) cation plot of miscellaneous intrusive rocks.....	319
Figure 41. AFM (Irvine and Baragar 1971) diagram of footwall mafic intrusive rocks below Michipicoten Iron Formation.....	320
Figure 42. Jensen (1976) cation plot of footwall mafic intrusive rocks below Michipicoten Iron Formation.....	321
Figure 43. AFM (Irvine and Baragar 1971) plot of Reed Lake mafic intrusive rocks.....	322
Figure 44. Jensen (1976) cation plot of Reed Lake mafic intrusive rocks.....	323
Figure 45. AFM (Irvine and Baragar 1971) plot of Sunrise Lake mafic to ultramafic intrusion.....	324
Figure 46. Jensen (1976) cation plot of Sunrise Lake mafic to ultramafic intrusion.....	325
Figure 47. AFM (Irvine and Baragar 1971) plot of pyroxenites, Chabanel Township.....	326
Figure 48. Jensen (1976) cation plot for pyroxenites, Chabanel Township.....	327

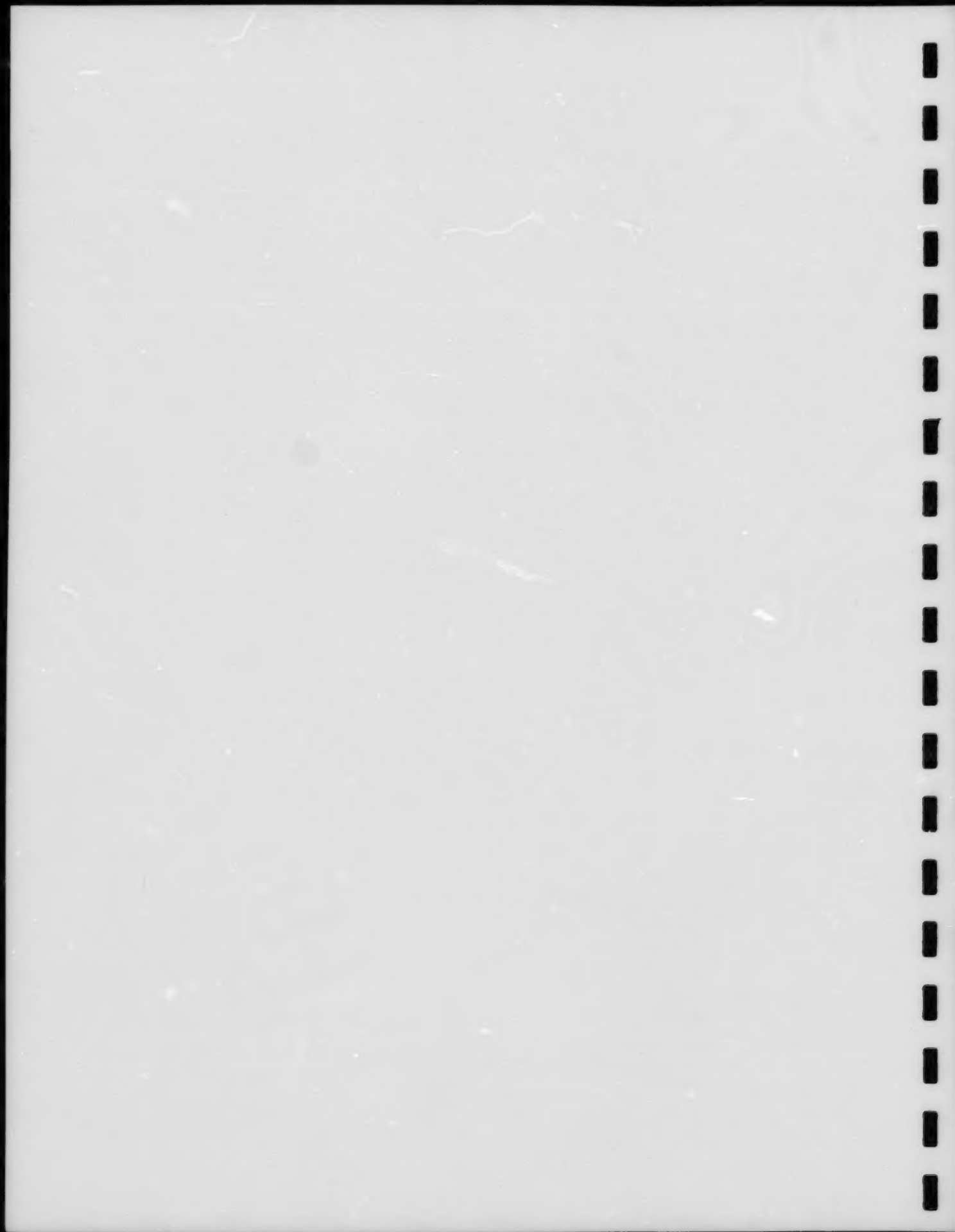


Figure 49. AFM (Irvine and Baragar 1971) plot of Hawk Lake Granitic Complex.....	328
Figure 50. Jensen (1976) cation plot for Hawk Lake Granitic Complex.....	329
Figure 51. Streckeisen (1976) plot of norms for the Hawk Lake Granitic Complex.....	330
Figure 52. AFM (Irvine and Baragar 1971) plot of quartz-feldspar porphyry intrusive rocks.....	331
Figure 53. Jensen (1976) cation plot for quartz-feldspar porphyry intrusions.....	332
Figure 54. Streckeisen plot using normative mineralogy of quartz feldspar porphyry intrusions.....	333
Figure 55. AFM (Irvine and Baragar 1971) diagram for Jubilee Stock.....	334
Figure 56. Jensen (1976) cation plot for Jubilee Stock.....	335
Figure 57. Streckeisen plot of normative mineralogy for Jubilee Stock.....	336
Figure 58. Schematic sketch of location of radioactive carbonate-rich lamprophyres along Highway 101.....	Back pocket
Figure 59. Jensen (1976) cation plot of cycle one mafic and felsic metavolcanic rocks.....	337
Figure 60. AFM (Irvine and Baragar 1971) plot of cycle one mafic and felsic metavolcanic rocks.....	338
Figure 61. Jensen (1976) cation plot of felsic and mafic metavolcanic rocks of cycle two.....	339
Figure 62. AFM (Irvine and Baragar 1971) plot of felsic and mafic metavolcanic rocks of cycle two.....	340
Figure 63. Idealized schematic of facies in Michipicoten Iron Formation. Note sharp upper and lower contacts and gradational internal contacts.....	341
Figure 64. Idealized composite stratigraphic section (D-E) for the Lucy Iron Range. Note stratigraphic position of the ferruginous dolomite and mafic breccia.....	342
Figure 65. Idealized composite stratigraphic section (A-B-C) for the Ruth and Josephine Iron Ranges. Note the stratigraphic position of the ferruginous dolomite and mafic breccia.....	343
Figure 66. Schematic diagram of diamond drilling on the Eleanor Iron Range.....	Back pocket
Figure 67. Schematic diagram of cross section through siderite ore body, Helen Iron Range showing pinch and swell characteristics of ore horizon.....	Back pocket
Figure 68. Schematic diagram of diamond drilling on the Helen Iron Range.....	Back pocket
Figure 69. Schematic diagram of diamond drilling on the Johnson Iron Range.....	Back pocket
Figure 70. Schematic diagram of diamond drilling on the Lucy Iron Range.....	Back pocket
Figure 71. Schematic diagram of diamond drilling completed by Regnery Mines Limited and Canabec Explorations Limited on Magpie Junction Gold Occurrence.....	Back pocket

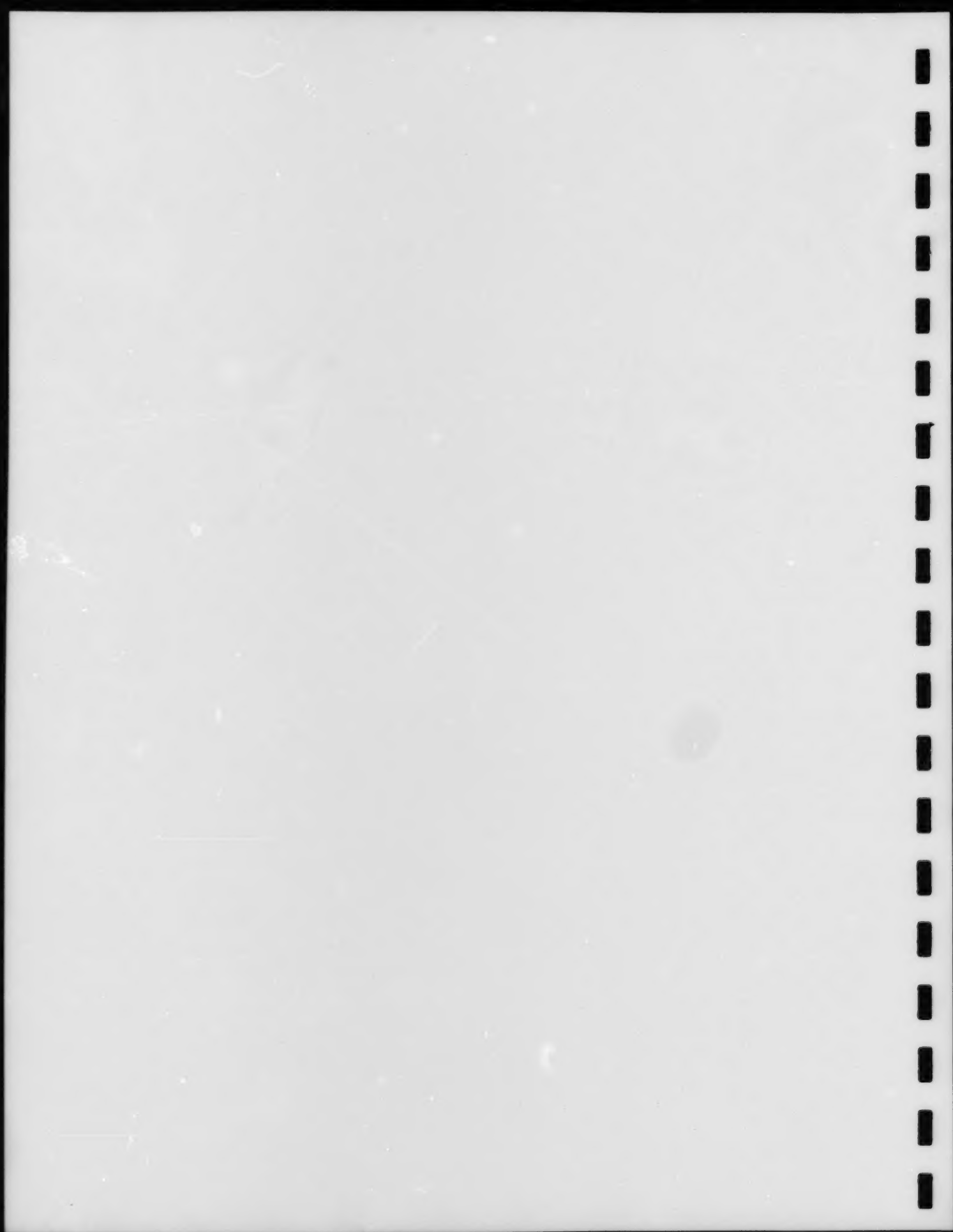


Figure 72. Schematic diagram of sample locations, Mammoth Metals Property.....	344
Figure 73. Schematic sketch of diamond drilling on Mr. E. Metvedt property.....	Back pocket
Figure 74. Schematic sketch of geology with diamond drill hole locations for Mildred Iron Range. Compiled from records of Jalore Mining Company Limited.....	Back pocket
Figure 75. Schematic sketch of J. Errington diamond drilling with indicated gold-bearing horizons. Precise location of grid unknown. Williamson Group (AFRO files, Toronto).....	345
Figure 76. Schematic sketch map with sample locations for Atnel Gold Occurrence.....	346
Figure 77. Schematic sketch map with sample locations for Joseph Bukell Copper Showing.....	347
Figure 78. Schematic sketch map of mineralized showings on the property of Firespur Explorations Limited.....	348
Figure 79. Compilation of diamond drill hole data and outcrop data for the Sunrise Lake Peridotite, Firespur Explorations Limited.....	Back pocket
Figure 80. Schematic sketch map with sample locations for Murray Algoma Mining Company Limited Gold Occurrence.....	349
Figure 81. Sketch map of Murray Algoma Mining Company Limited Gold Occurrence (AFRO, Toronto).....	350
Figure 82. Schematic sketch map of Ruth Iron Range with diamond drill hole locations.....	Back pocket
Figure 83. Geologic sketch map of Soocana Reed-Booth Gold Occurrence. Modified after sketch map by Sylvanite Gold Mines Limited (1940) (AFRO, Toronto).....	351
Figure 84. Schematic sketch map of Aldo Palmo Molybdenite Occurrence (AFRO, Toronto).....	Back pocket
Figure 85. Schematic plan view of underground workings and ore bodies projected to surface of Citadel Gold Mines Incorporated.....	Back pocket
Figure 86a, Plan maps indicating position of diamond drill holes.....	Back pocket
Figure 86b, c. on Citadel Gold Mines Incorporated Property. Assays greater than 0.10 ounces per ton gold indicated on maps.....	Back pocket
Figure 87. Sketch map showing location of diamond drill holes of Mrs. C. Blanche with respect to shaft of Deep Lake mine.....	Back pocket
Figure 88. Schematic sketch map of Dunraine Mines Limited property indicating showings and position of diamond drill holes.....	Back pocket

List of Photographs

Photo 1. Abandoned dam and power house at Steep Hill Falls on the Magpie River. Photo taken in 1980.....	352
--	-----



Photo 2a. Treeless area north and west of McLeod shaft Helen Iron Range. Photo taken looking southeast. Top of headframe of MacLeod shaft on horizon.....	352
Photo 2b. Polysutured basaltic komatiite, Esquega Township. See sample 79-0072. Location P-34.....	353
Photo 2c. Polysutured pillowed komatiite, Esquega Township. Location P-35.....	353
Photo 3. Coarse intermediate to felsic metavolcanic breccia northwest of the McLeod shaft and footwall to Helen Iron Range. Some clasts display a distinct bleaching of clast rims. Location P-1.....	354
Photo 4. Polymictic breccia with clasts weathering in relief. South of Sunrise Lake, Esquega Township. Location P-2.....	354
Photo 5. Possible fiamme in ash flow footwall to the Helen Iron Range. McMurray Township. Location P-3.....	355
Photo 6. Thin bedded intermediate to felsic metavolcanic tuff east of sinter plant of Algoma Ore Properties Limited. McMurray Township, Location P-4.....	355
Photo 7. Cross bedding in fine grained tuff of intermediate to felsic metavolcanic. McMurray Township. Location P-4.....	356
Photo 8. Undulatory contact between fine grained tuff (top) and underlying lapilli tuff. Note draping of fine grained tuff over larger fragments. McMurray Township, Location P-4.....	356
Photo 9. Hollow spherulites in felsic flow at west end of Wawa Lake. McMurray Township, Location P-5.....	357
Photo 10. Coarse intermediate to felsic metavolcanic breccia of cycle two volcanism centered north of the Magpie River, Chabanel Township. Location P-6.....	357
Photo 11. Coarse intermediate to felsic breccia north of abandoned power dam at Steep Hill Falls, Magpie River, Chabanel Township. Location P-7. Matrix of this breccia more chloritic than clasts.....	358
Photo 12. Well bedded angular block of Jubilee tuff in granitic matrix of the Jubilee Stock. Intrusive breccia characterizes the east margin of the Jubilee Stock. Note lack of reaction rims or assimilation. Stanley Lake area, McMurray Township. Location P-8.....	358
Photo 13. Subrounded to subangular clast of feldspar porphyry displaying good bleached reaction rim. Stanley Lake area, McMurray Township. Location P-9.....	359
Photo 14. Graded bedding in wacke to subarkose bed between thin beds of siltstone to mudstone. Chabanel Township, Location P-10.....	359
Photo 15. Flame structures, graded bedding, and soft sediment slump features. North of the Magpie River, Chabanel Township. Location P-11.....	360
Photo 16. Flame structures in wacke displaying good grain gradations (not visible in photo). Flame structures indicate south facing stratigraphy in a north dipping sequence. Chabanel Township location P-12.....	360

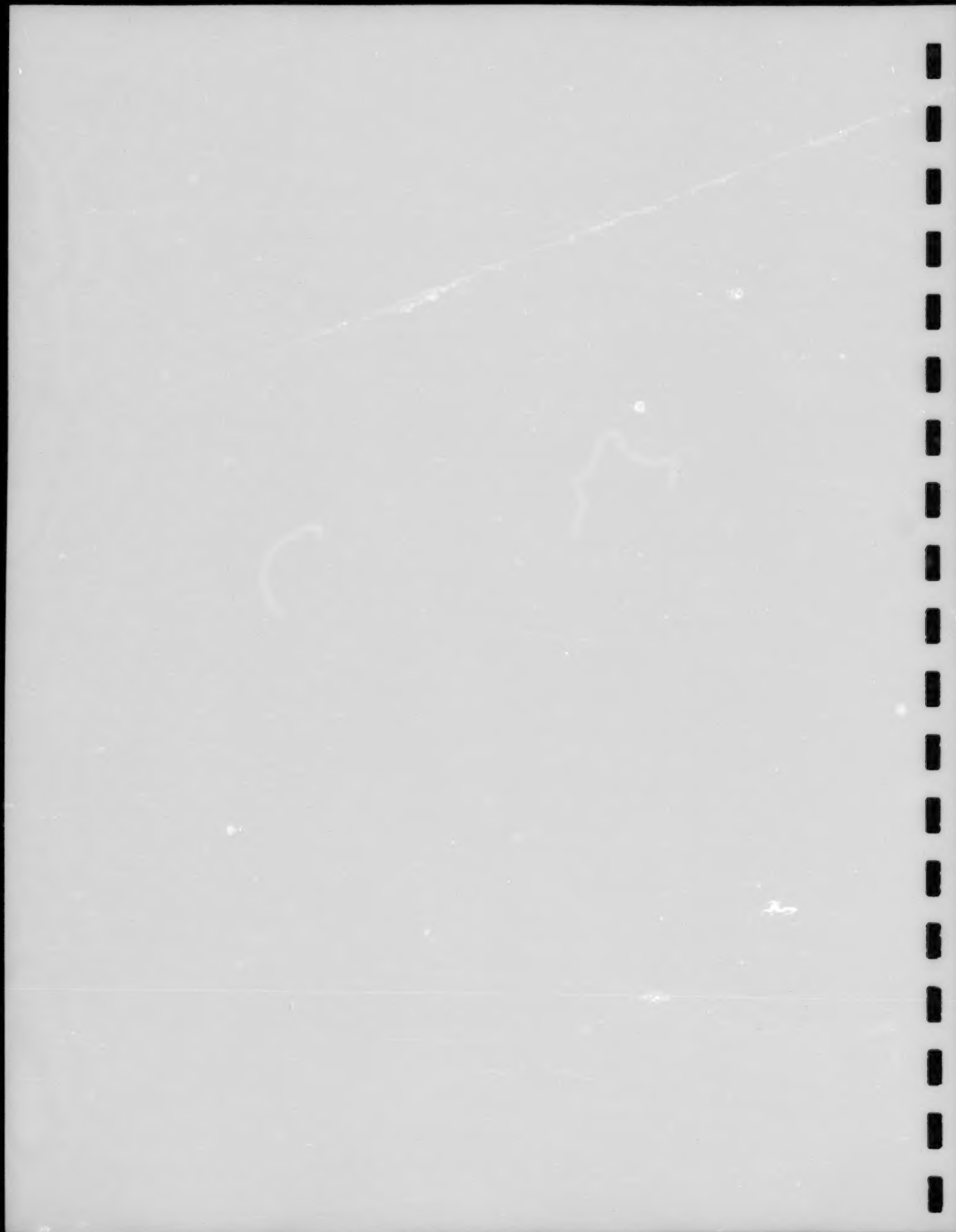


Photo 17. Graded bedding and soft sediment slump structures, Steep Hill Falls area, Chabanel Township. Location P-13.....	361
Photo 18. Chert pebble conglomerate near base of sedimentary section above Lucy Iron Range. Chert varies from massive to finely laminated and from subangular to rounded. Chabanel Township. Location P-14.....	361
Photo 19. Drap structures over rounded laminated chert cobbles in chert pebble conglomerate near base of section above Lucy Iron Range, Chabanel Township. Location P-15.....	362
Photo 20. Clast supported chert pebble conglomerate near base of metasedimentary section above Lucy Iron Range. Note subrounded to subangular shape of clasts, Chabanel Township, Location P-16.....	362
Photo 21. Excellent trough cross bedding in metasedimentary rocks above Lucy Iron Range. Esquega Township. Location P-17...	363
Photo 22. Soft sediment slump structures in metasedimentary rocks above Lucy Iron Range. Chabanel Township. Location P-18.....	363
Photo 23. End of view of climbing ripples in metasedimentary rocks above Lucy Iron Range. Chabanel Township. Location P-19.....	364
Photo 24. Desiccation cracks in metasedimentary rocks above Lucy Iron Range. Esquega Township. Location P-20.....	364
Photo 25. Ripple marks on numerous bedding surfaces in wacke metasedimentary rocks north of Mildred Lake. Chabanel Township. Location P-21.....	365
Photo 26. Close up of ripple marks on one bedding surface in wacke metasedimentary rocks north of Mildred Lake. See Plate 25 for view of outcrop. Location P-21.....	365
Photo 27. Ripple marks in wacke metasedimentary rocks at the north end of Bauldry Lake Esquega Township. Location P-22.....	366
Photo 28. Thin bedded chert-wacke-magnetite in upper portion of Helen Iron Range. Chabanel Township. Location P-23.....	366
Photo 29. Upper contact of Eleanor Iron Range with base of overlying mafic flow of cycle two volcanic rocks. Contact of argillite-pyrite facies of iron formation immediately to left of person in photo. Chabanel Township. Location P-24.....	367
Photo 30. Interbedded chert-wacke iron formation in the upper part of the Lucy Iron Range. Chabanel Township. Location P-25. Note the alteration of brecciated and unbrecciated iron formation.....	367
Photo 31. Close up of one wacke bed in chert-wacke facies of iron formation of the Lucy Iron Range. Same site as Plate 30. Note grain gradation within tuff forming wacke bed, Chabanel Township. Location P-25. Tops are north on grain gradation consistent with topping directions based on pillows within intermediate to mafic metavolcanic rocks directly above iron range.....	368
Photo 32. Grading of fragment size in lapilli tuffs immediately below Helen Iron Range. Cement to the tuff is siderite. Chabanel Township. Location P-26.....	368

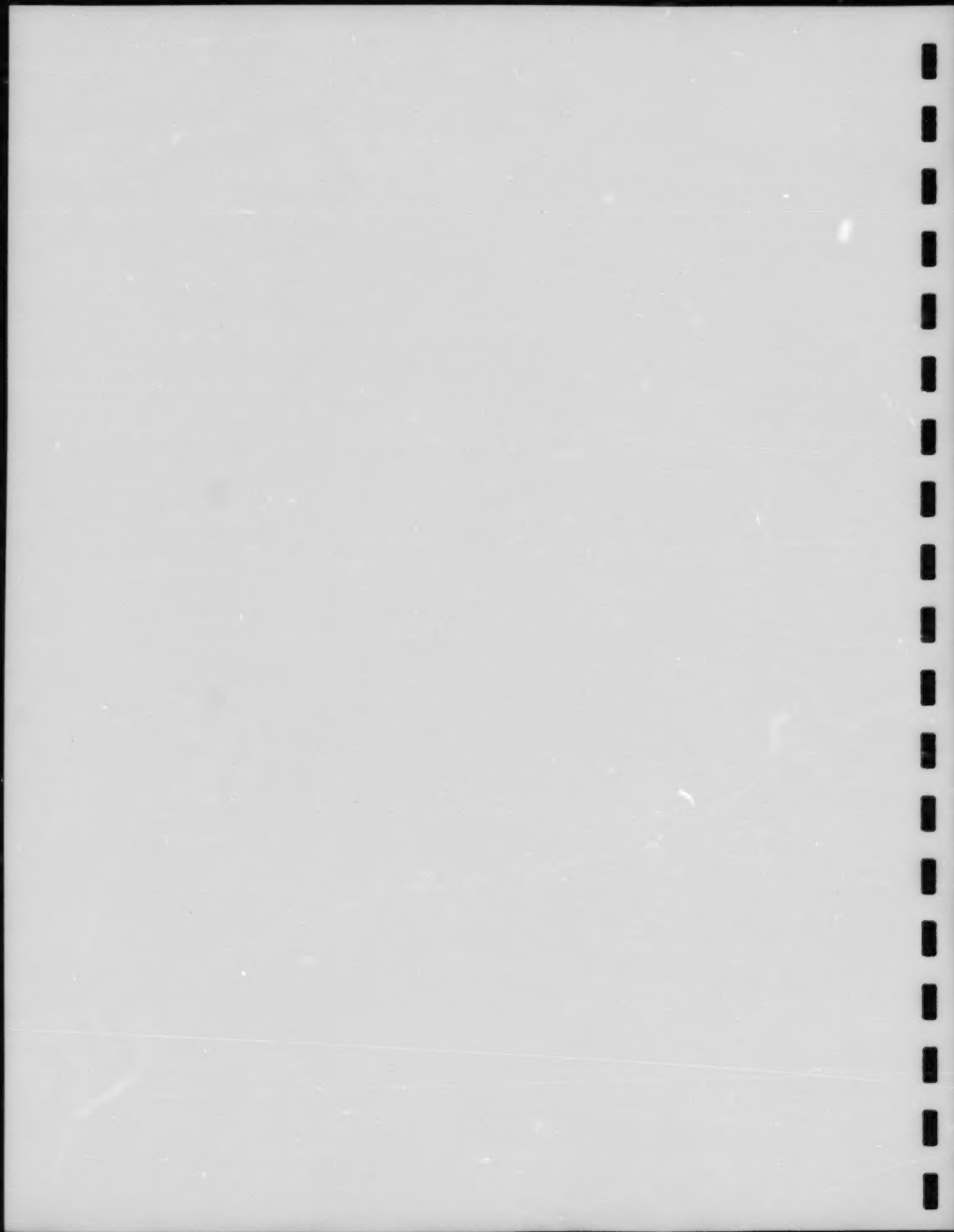
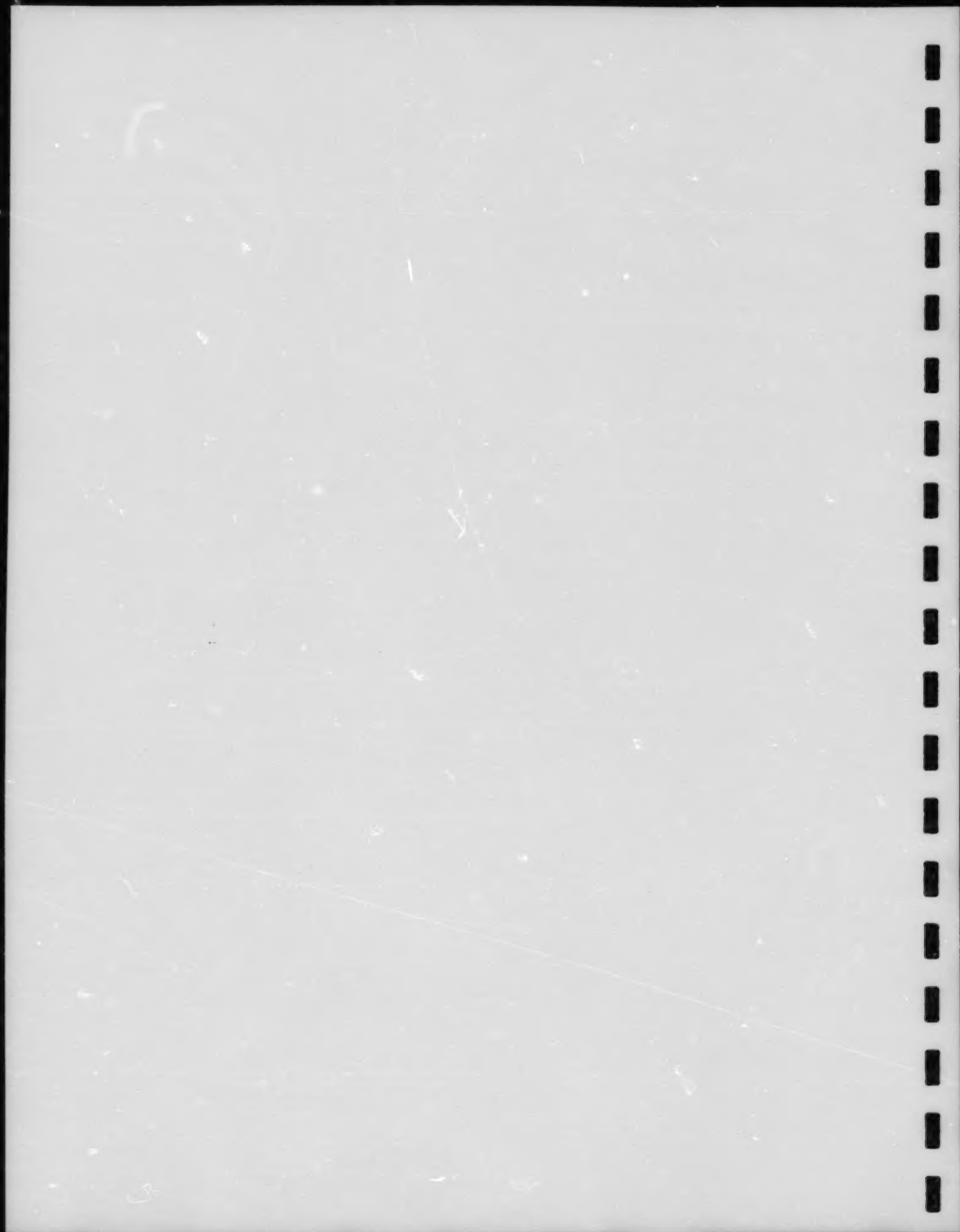


Photo 33. Hydroexplosion breccia below the Lucy Iron Range. Breccia is cemented with siderite. Chabanel Township. Location P-27.....	369
Photo 34. Hydroexplosion breccia below Helen Iron Range. Breccia cemented with siderite. Chabanel Township. Location P-28.....	369
Photo 35. Chloritoid selectively replacing clasts in preference to matrix. Chabanel Township. Location P-29. Alteration of clast may precede incorporation in tuff.....	370
Photo 36. Chloritoid occurring along fractures. These fractures were probably cooling cracks that permitted access of hydrothermal fluids. Chabanel Township. Location P-30.....	370
Photo 37. Tight folding in chert-wacke-magnetite iron formation at the west end of the Helen Iron Range, Chabanel Township. Location P-31.....	371
Photo 38. North facing pillows in first flow above Eleanor Iron Range. This is the base of cycle two volcanism. Chabanel Township. Location P-32.....	371
Photo 39. Top of shaft on Soocana Reed-Booth Gold Showing. Esquega Township.....	372
Photo 40. Surface buildings of Citadel Gold Mines Incorporated. McMurray Township.....	372
Photo 41. Reworked tuffs along south side of Parkhill Vein. Small scours and flame structures present in addition to well developed grain gradations. McMurray Township. Location P-33.....	373
Photo 42. Steel frame above vertical shaft on Darwin property of Dunraine Mines Limited. Photo taken in 1985.....	373
Photo 43. Exploration and testing of old workings of former Parkhill mine by Dunraine Mines Limited. The exploration headframe is as in appeared in 1985.....	374
Photo 44. Darwin Property as it appeared in 1908 and known as the Grace Gold Mine, photo from Wawa Chamber of Commerce.....	374
Photo 45. Equipment remaining at the site of the Golden Reed Gold Mines Limited. Photo taken in 1980.....	375
Photo 46. Golden Reed Gold Mines Limited as it appeared in 1908, photo from Wawa Chamber of Commerce.....	375

Maps

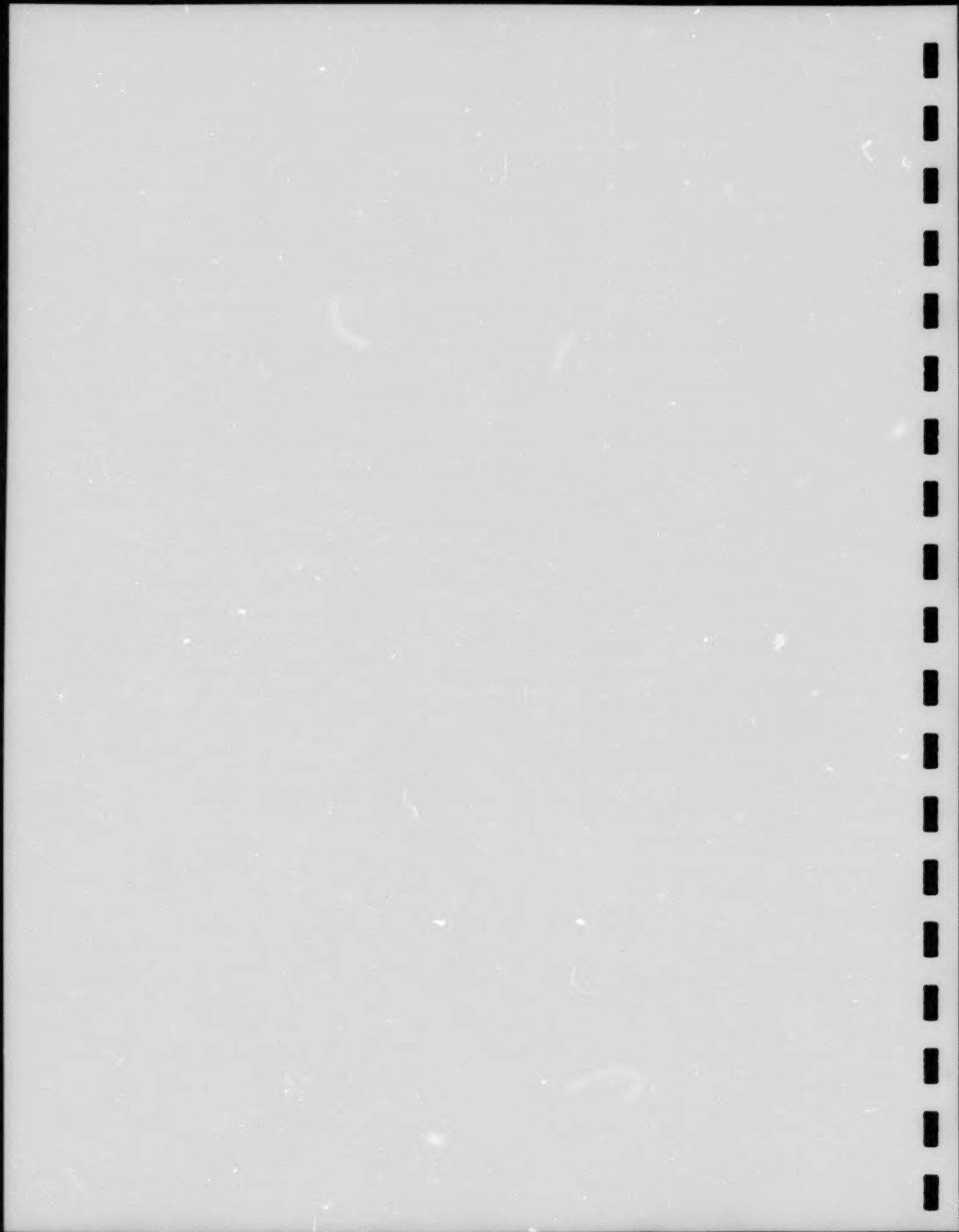
P.2439 Geological map of Chabanel Township.....	Back pocket
P.2440 Geological map of Esquega Township.....	Back pocket
P.2441 Geological map of McMurray Township.....	Back pocket
P.2442 Geological map of Lastheels Township.....	Back pocket

Compilation maps (1-6) of Chabanel, Esquega, McMurray and Lastheels townships.....	Back pocket
--	-------------

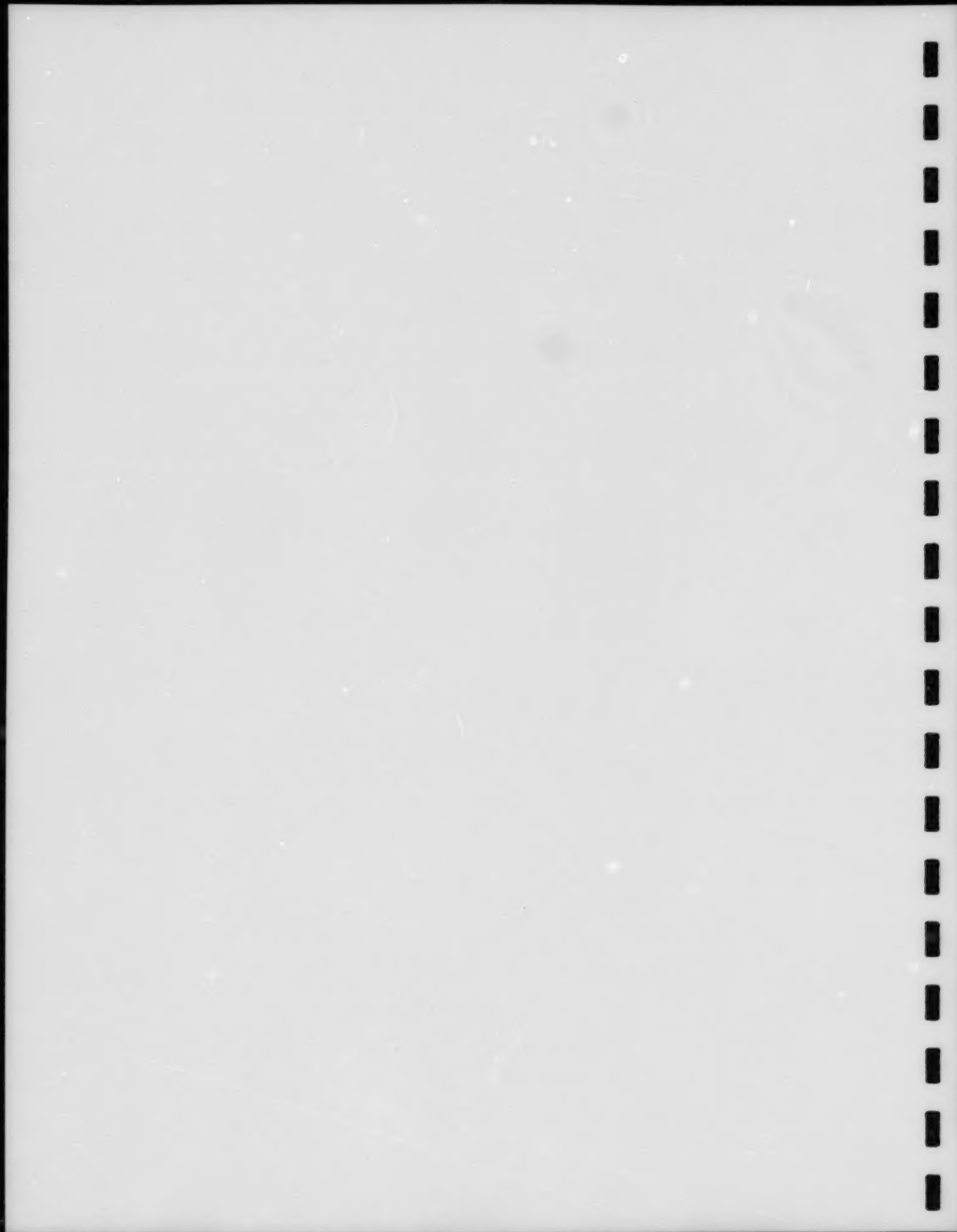


APPENDIX I

Description of Properties.....	376
Chabanel Township.....	376
Algoma Ore Properties Limited (1)	
Assessment Drill Hole A-1 (1-A)	
Assessment Drill Hole A-2 (1-B)	
Assessment Drill Hole A-4 (1-C)	
Assessment Drill Hole A-5 (1-D)	
Assessment Drill Hole A-8 (1-E)	
East of Brooks Lake (1-F)	
Eleanor (Lena)-Arlic Lakes area (1-G)	
Lena Lake (1-H)	
Michipicoten Base Metals Project (1-I)	
Anomaly 17C (1-I1)	
Anomaly 11B (1-I2)	
Anomaly 15 (1-I3)	
Mildred Lake Property (1-J)	
Moran Lake (1-K)	
Wallbank Lake (1-L)	
Anderson Property (2)	
Boliden Showing (3)	
Erie Canadian Mines Limited	
Hollinger Consolidated Gold Mines Limited	
Canamax Resources Incorporated	
Eleanor Iron Range (4)	
James Richardson and Sons Limited	
Algoma Ore Properties Limited	
Helen Iron Range (5)	
Hemgold Resources Limited (6)	
Jalore Mining Company Limited (7)	
Lucy Sand Flats (7-A)	
Johnson Iron Range (8)	
Lucy Iron Range (9)	
Michipicoten Iron Mines Limited	
Jalore Mining Company Limited	
Algoma Steel Corporation Limited	
Magpie Junction Gold Occurrence (10)	
Regnery Mines Limited	
Erie Canadian Mines Limited	
Algoma Central and Hudson Bay Railway Company	
Hucliff Porcupine Mines Limited	
Canabec Explorations Limited	
Canamex Resources Incorporated	
Mammoth Metals Occurrence (11)	
Dome Mines Limited	
Mammoth Metals Incorporated	
Algoma Ore Properties Limited	
Manzutti Property (12)	
E. Metvedt Property (13)	



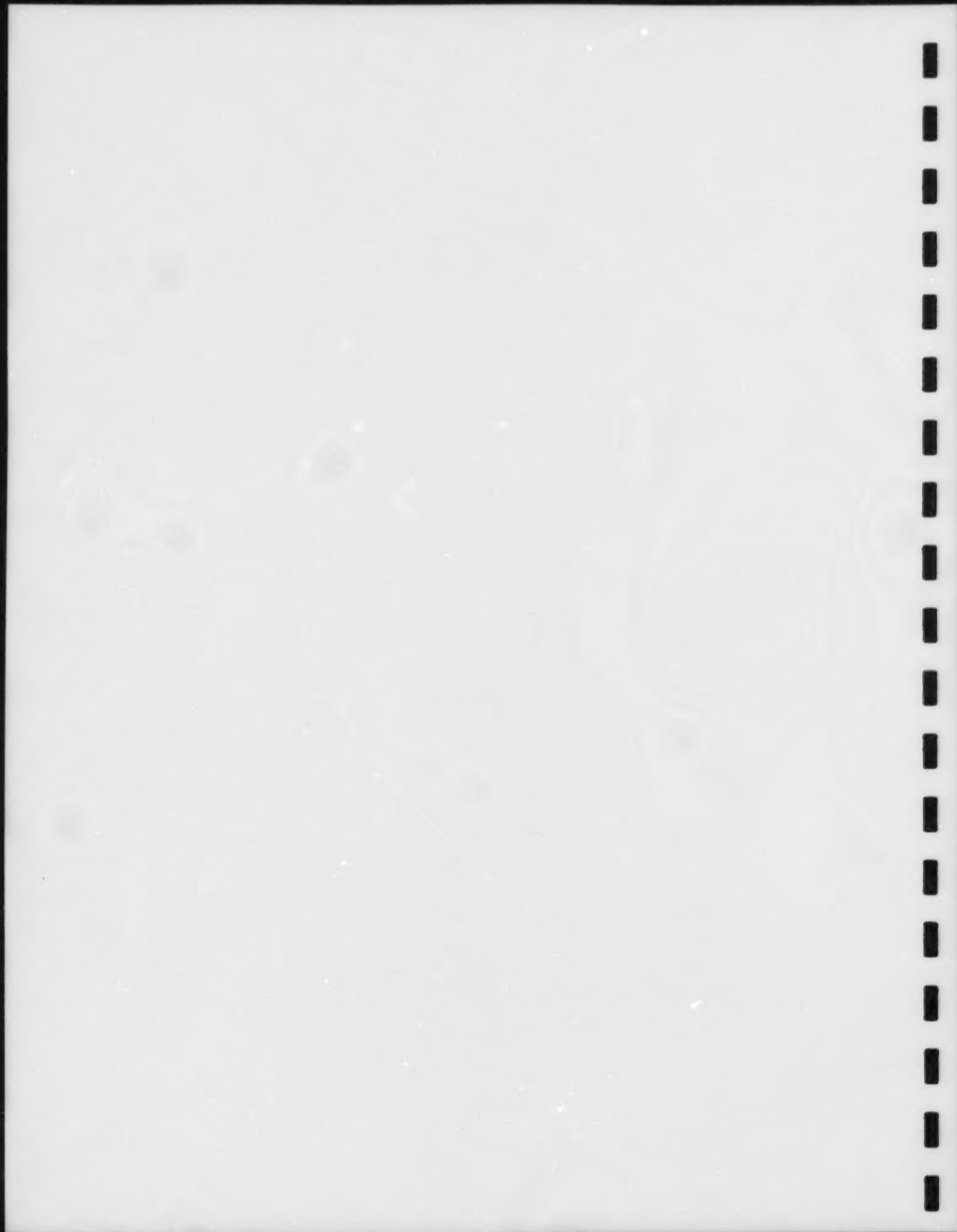
Mildred Iron Range (14)
 Jalore Mining Company Limited
 Mile 12 Iron Formation (15)
 Miller Group (16)
 Hollinger Consolidated Gold Mines Limited
 Erie Canadian Mines Limited
 Phelps Dodge Corporation of Canada (17)
 Grid N (17-A)
 Grid W (17-B)
 Grid West (17-C)
 Sinclair Property (18)
 E. Metvedt
 Wilks-Arnott Iron Range (19)
 Jalore Mining Company Limited
 Williamson Group (20)
 J. Errington
 Erie Canadian Mines Limited
 Hollinger Consolidated Gold Mines Limited
 Esquega Township.....395
 Amax Exploration Incorporated (21)
 Algoma Ore Properties Limited (22)
 Assessment Drill Hole A-3 (22A)
 Assessment Drill Hole A-6 (22B)
 Loonskin Lake Area (22C)
 Michipicoten Base Metal Project (22D)
 Anomaly 17C (22D1)
 Anomaly 27D (22D2)
 Wagner Anomaly 14b (22E)
 Atnel Gold Occurrence (23)
 Atnel Gold Mines Limited
 Erie Canadian Mines Limited
 Howey Gold Mines Limited
 Unknown
 J-Q Resources Limited
 Belyea Syndicate (24)
 Claim AC 7414 (24A)
 Claim AC 7318 (24B)
 Biaglioni - Calabani Group (25)
 Black Smith Vein (26A)
 Atnel Gold Mines Limited
 Erie Canadian Mines Limited
 J.Q. Resources (26A and 26B)
 Bukell Copper Showing (27)
 Falconbridge Limited (28)
 Firespur Exploration Limited (29A)
 Number 1 Vein (29B)
 B, C, and H Vein (29C)
 Vein E (29D)
 Vein F (29A)
 Vein J (29E)



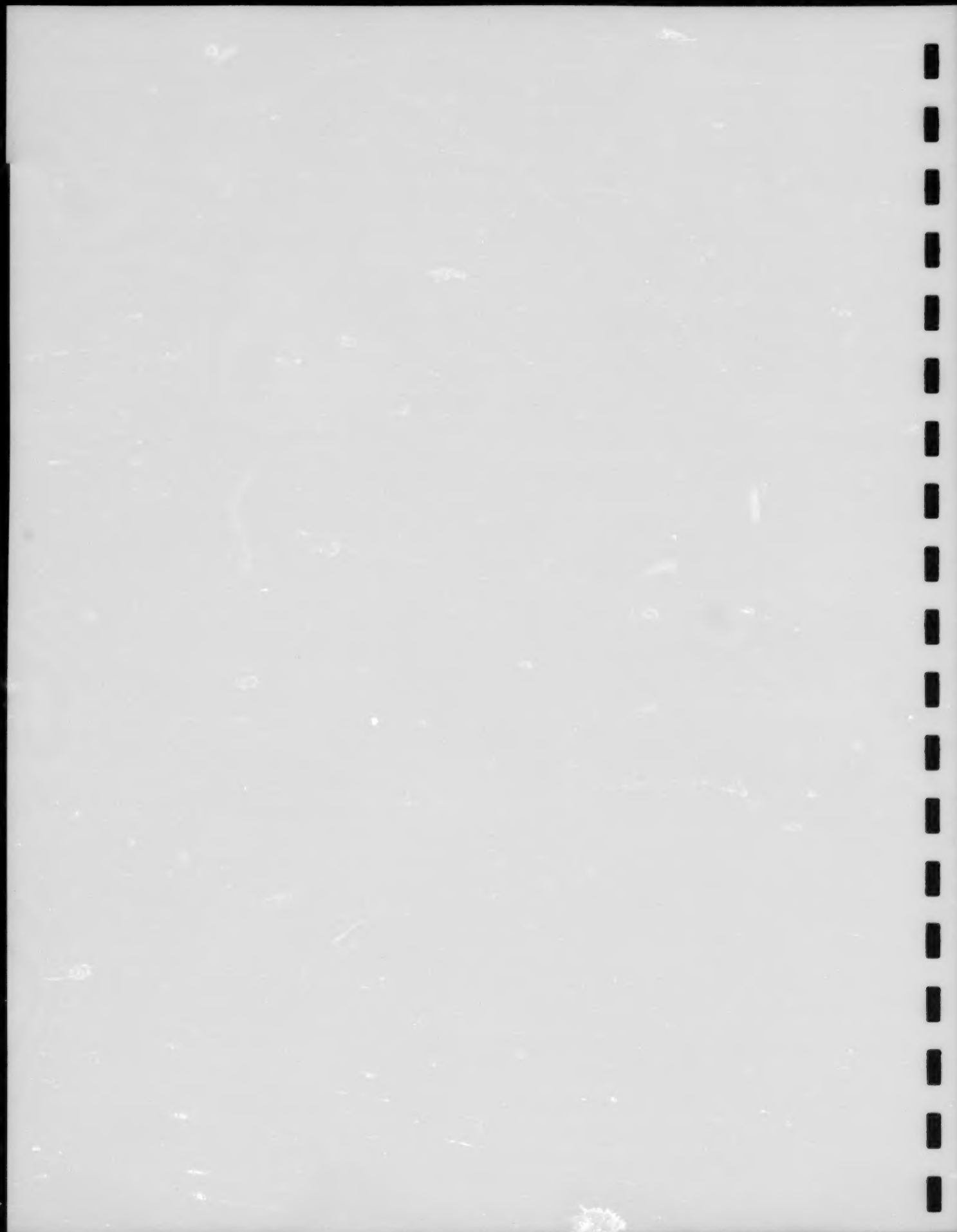
Engineers Holding Company
 Corinth Mines Limited
 Sylvanite Gold Mines Limited
 Lakemount Mines Limited
 N.A. Timmins Limited
 Kelore Mines Limited
 Ventures Limited
 New Kelore Mines Limited
 Algoma Ore Properties Limited
 Selco Exploration Company Limited
 Shield Development Company
 Jalore Mining company Limited (51)
 (see Judith Iron Range McMurray Township)
 Kathleen Iron Range (30)
 (Macauley Iron Prospect)
 Algoma Ore Properties Limited
 Murray Algoma Gold Occurrence (31)
 Murray Algoma Mining Company Limited
 J-Q Resources Limited
 Pango Gold Mines Limited (32)
 Reqnery Metals Molybdenite Occurrence (33)
 Reqnery Metals Limited
 International Ranwick Limited
 Ruth Iron Range (34)
 Bethlehem Steel Corporation
 Michipicoten Iron Mines Limited
 Jalore Mining Company Limited
 Algoma Steel Corporation Limited
 Soocana Reed - Booth Gold Showing (35)
 Sylvanite Gold Mines Limited
 Lastheels Township.....416
 Aldo Palma Molybdenite Showing (36)
 (formerly Peters-Quilty property)
 Falconbridge Mines Limited
 Deep Lake Gold Mines Limited
 Pax International Mines Limited
 International Ranwick Limited
 International Molybdenum Mines Limited
 Billiton Maatschappij N.V.
 Amax Minerals Exploration Limited
 Firesand River Carbonatite
 Mid North Engineering (37)
 Pango Gold Mines Limited
 McMurray Township.....420
 Algoma Ore Properties Limited (38)
 Assessment Drill Hole A-7 (38-A)
 Assessment Drill Hole A-9 (38-B)
 Michipicoten Base Metal Project (38C)
 Anomaly 12 (38C-1)
 Anomaly 30 (38C-2)



Anderson Property (39)
 Erie Canadian Mines Limited
 Hollinger Consolidated Gold Mines Limited
 Surluga Gold Mines Limited
 Barton Property (40)
 Hollinger Consolidated Gold Mines Limited
 Big Dome Prospect (41)
 Blanche, C. Mrs. (46)
 (See Deep Lake Mine)
 Bohme, J.D.S. (42)
 (see Pango Gold Mines Limited under Citadel Gold Mines
 Incorporated)
 Citadel Gold Mines Incorporated (42)
 formerly Surluga Gold Mines Limited
 formerly Pango Gold Mines Limited
 formerly Pursides Gold Mines Limited
 Sutherland and Company
 Surluga Gold Mines Limited
 Consolidated Mining and Smelting Limited
 Pango Gold Mines Limited (42 and 42A)
 Cooper Mine and Ganley Vein (42B)
 Cooper Gold Mines Limited
 Minto Gold Mines Limited
 Cora Gold Mines Limited (42)
 Hornblende Property (42C)
 Hornblende Mining Company Limited
 Jubilee Mine (42D)
 Great Northern Mining Co. Limited
 Cooper Gold Mines Limited
 Minto Gold Mines Limited
 Mackey Point (42E)
 Consolidated Mining and Smelting Company of Canada
 Limited
 Mackey Point Gold Mines Limited
 Minto Gold Mine (42F)
 Cooper Gold Mines Limited
 Minto Gold Mines Limited
 Wawa Goldfields Limited (42G)
 Consolidated Bellekeno Mines Limited (43)
 Consolidated Mining and Smelting Company of Canada Limited (44)
 Consolidated Morrison Exploration Limited (45)
 Cooper Mine and Ganley Vein (42B)
 (see Citadel Gold Mines Incorporated)
 Cora Property (42)
 (see Citadel Gold Mines Incorporated)
 Darwin Gold Mines Limited (47A)
 (see Dunraine Mines Limited)
 Deep Lake Gold Mine (46)
 Deep Lake Gold Mines Limited
 Blanche, C. Mrs.



Golden Goose Gold Mines Limited
 Dunraine Mines Limited (47)
 Darwin (Grace) Mine - Geology
 Parkhill Mine - Geology
 Darwin Gold Mines Limited (47A)
 Algoma Commercial Company
 LePage Gold Mining Company
 Grace Mining Company
 A - Gold-Ma Mining Syndicate
 United Algoma Mines Limited
 The Power and Mines Corporation Limited
 Darwin Gold Mines Limited
 Mariposa Prospect (Blackinton Vein) (47B)
 Edey Gold Mining Company
 Mariposa Gold Mining Company
 Dunraine Mines Limited
 Parkhill Mine (47C)
 Cooper Gold Mines Limited
 Parkhill Gold Mines Limited
 Ward Lake Gold Mines Limited
 Edina Property (48)
 Edina Gold Syndicate
 Asarco Company of Canada Limited
 Nakusp Resources Limited
 Welcome North Mines Limited
 Firesand Carbonatite
 (see Smye 1983)
 Gibson Property
 Golden Goose Mines Limited (46)
 (see Deep Lake Gold Mine)
 Golden Reed Gold Mines Limited (49)
 Grace Gold Mine (47A)
 (see Dunraine Mines Limited)
 Henderson Property
 Hillside Prospect (50A, 50B)
 Hornblende Property (42C)
 (see Citadel Gold Mines Incorporated)
 Jubilee Gold Mines (42D)
 (see Citadel Gold Mines Incorporated)
 Judith Iron Range (51)
 Jalore Mining Company Limited
 Laccolith Property (52)
 Lake Osu Mines Limited (53)
 LeRoy Property (54)
 Lloyd Gold Mines (55)
 Mackey Point Mines Limited (42E)
 (see Citadel Gold Mines Incorporated)
 Mariposa Prospect (4713)
 (see Dunraine Mines Limited)
 McMarmar Red Lake Gold Mines Limited (56)



McPhail, Goodman, Burns, and Leishonan Group
Michipicoten Gold Mines Limited (57A)

(see Van Sickle Mine)

Big Carbonate Vein

Captain Vein

Creek Vein

Great Northern Vein

Lucky Strike Vein

Mickelson Vein (57B)

Sunrise Vein (52)

(see Sunrise Prospect)

Wilcox Vein

Van Sickle Vein (63)

(see Van Sickle Mine)

Milmac Mines Limited

Minto Gold Mines Limited (42F)

(see Citadel Gold Mines Incorporated)

Morrison Property (58)

Northern Horizon Resources Limited (59)

Nyman, W. (60)

Pango Gold Mines Limited (42)

(see Citadel Gold Mines Incorporated)

Parkhill Gold Mines Limited (47C)

(see Dunraine Mines Limited)

Peterson Group

Pursides Gold Mines Limited (42)

(see Citadel Gold Mines Incorporated)

Shier Group

Soo Mining Company

S.B. Smith Mine (63)

(see Van Sickle Mine)

Stanley Gold Mine (61)

Marboy Mines Limited

Sunrise Prospect (62)

Parkhill Gold Mines Limited

Michipicoten Gold Mines Limited

Trembly Claims

Van Sickle Mine (63)

S.B. Smith

Michipicoten Gold Mines Limited

Dunraine Mines Limited

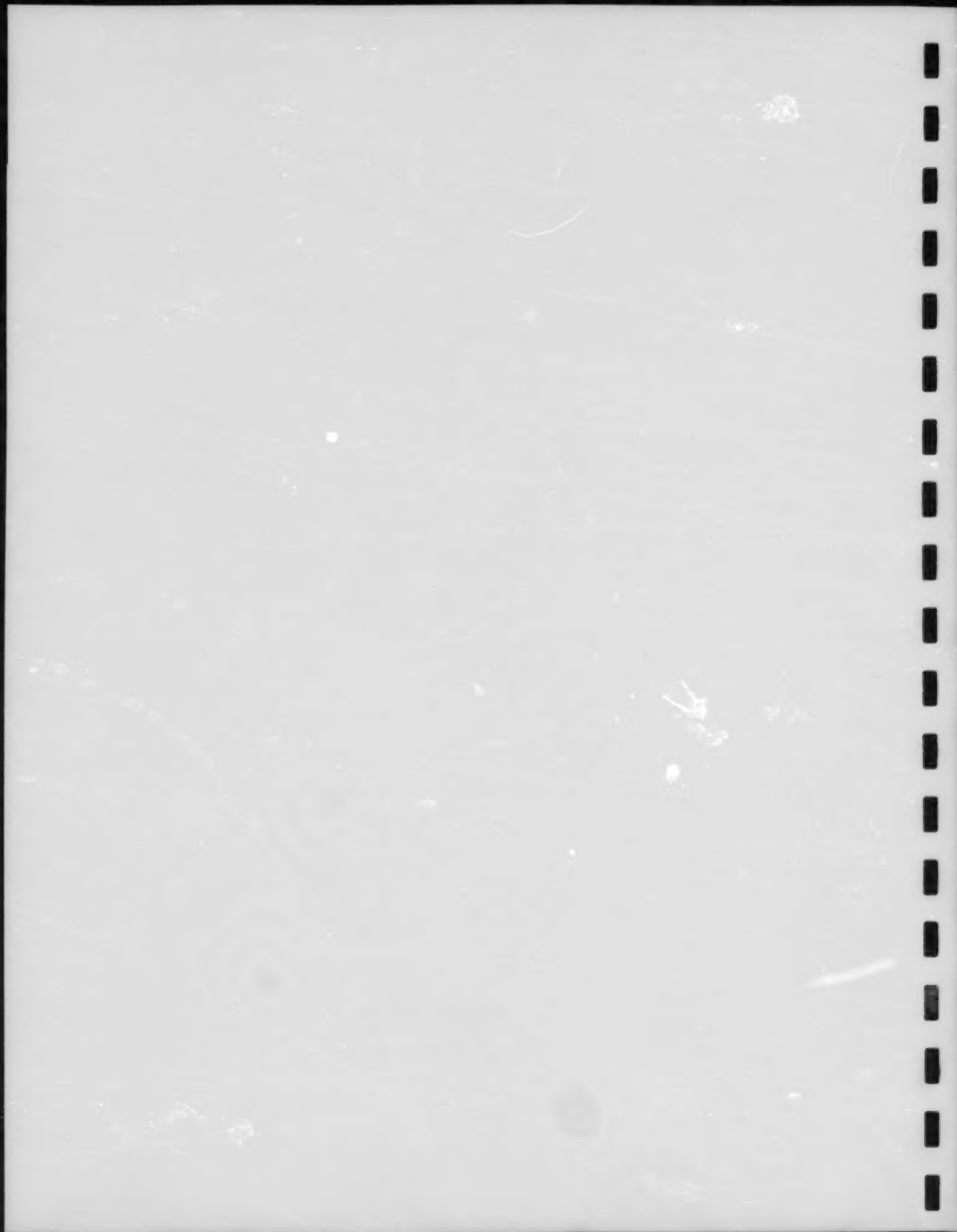
Wawa Goldfields (42G)

(see Citadel Gold Mines Incorporated)

War Eagle (64)

Villeneuve Property

Conversion Table.....462



ABSTRACT

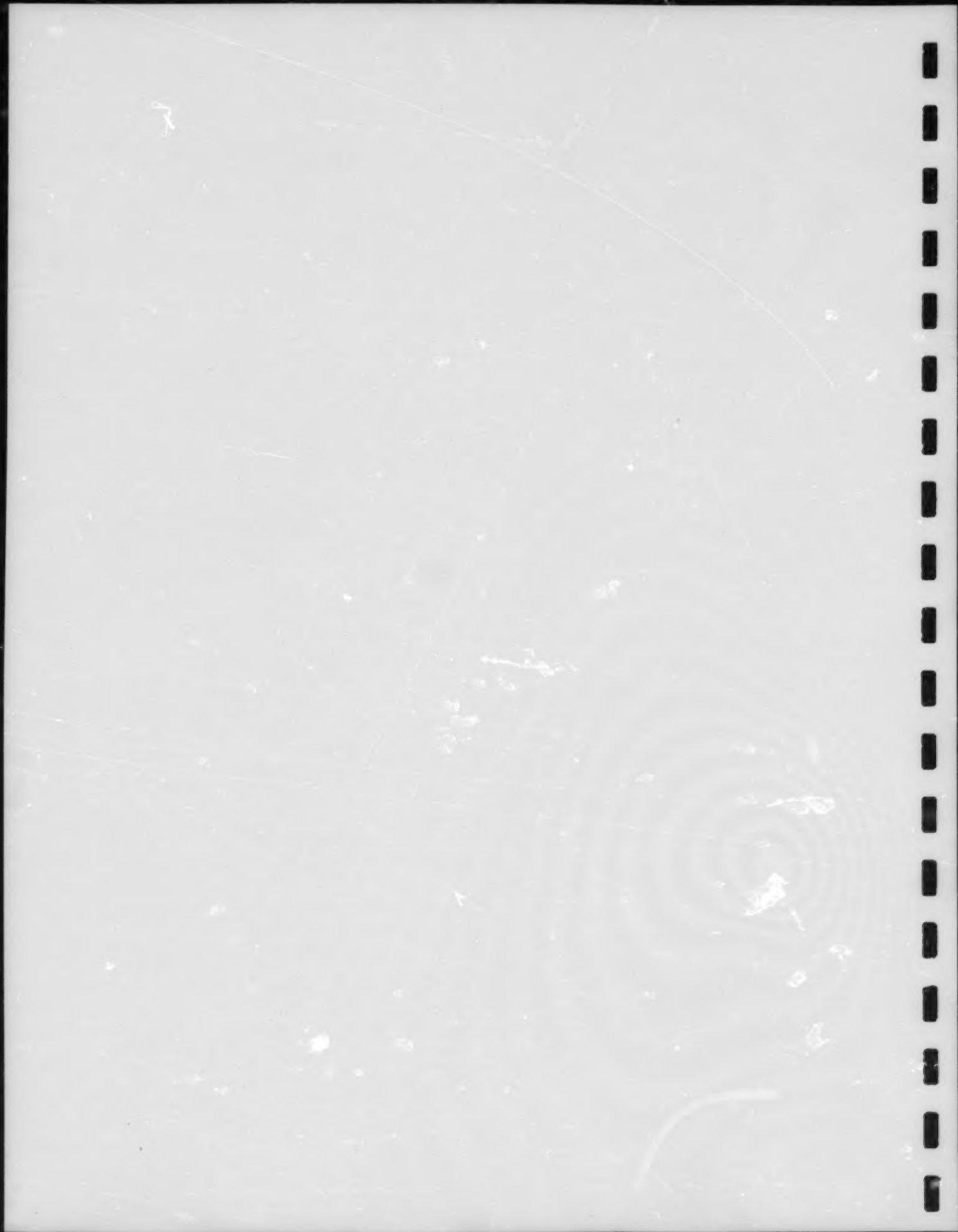
The map area is underlain dominantly by Archean rocks. The rocks are dominantly of intermediate to mafic and intermediate to felsic composition. The intermediate to mafic metavolcanic rocks, are principally massive and pillowed flows. The intermediate to felsic metavolcanic rocks are dominantly flows, tuffs, lapilli tuffs, breccias, feldspar crystal tuffs, quartz-feldspar crystal tuffs and spherulitic flows. Coarse to very coarse breccias in proximity to the town of Wawa imply that there was an Archean volcanic vent in the immediate vicinity. Metasedimentary rocks deposited both in shallow and deep water were derived by erosion of the volcanic rocks. The metasedimentary rocks consist of conglomerate, wacke, siltstone and argillite.

Iron formation lies on top of a major unit of intermediate to felsic metavolcanic rocks that extends northeast from Wawa through the northwest corner of Esquega Township. The iron formation separates volcanism of cycle one from that of cycle two. A subcycle within cycle one is represented by a discontinuous band of intermediate to felsic metavolcanic rocks that extends from the northwest corner of McMurray Township to the north-central part of Esquega Township. This subcycle is also locally capped with iron formation.

Above the iron formation capping cycle one, intermediate to mafic volcanic flows lie conformably on top of the iron formation. Above the intermediate to mafic volcanic rocks a thick section of clastic sedimentary rocks extends from the west boundary of Chabanel Township to and beyond the northeast corner of Chabanel Township. These sedimentary rocks interfinger with fine to coarse intermediate to felsic fragmental rocks of cycle two north of the Magpie River. The clastic sedimentary rocks are the product of erosion of intermediate to felsic cycle two volcanic centre rocks.

In the northwest corner of Chabanel Township intermediate to mafic volcanic flows lie conformably above the sedimentary rocks suggesting that a third period of volcanism has occurred.

The metavolcanic rocks and metasedimentary rocks are intruded by numerous mafic to ultramafic intrusions that range in composition from quartz diorite, diorite, and gabbro to peridotite. While it is unlikely that these mafic to ultramafic intrusions were intruded during a single geologic event the establishment of age relations between the various mafic intrusions is difficult. Quartz-feldspar porphyries intrude the metavolcanic rocks, metasedimentary rocks, and mafic intrusions. These porphyritic rocks are common in the eastern part of McMurray Township and form a major rock type in Esquega Township. In McMurray Township the quartz-feldspar porphyry



forms an arcuate body, possibly occupying a ring fracture, that partially encloses the Jubilee Stock. In Esquega Township the quartz-feldspar porphyry forms a marginal phase to the Hawk Lake Granitic Complex which has intruded the base of the volcanic sequence. The quartz-feldspar porphyrys in Esquega Township do not extend above the discontinuous band of intermediate to felsic metavolcanic rocks of subcycle one that extends from the southwest corner to the north-central part of the township. The quartz-feldspar porphyry intrusions in McMurray and Esquega townships are likely of two different ages and related to the Jubilee Stock and Hawk Lake Granitic Complex respectively.

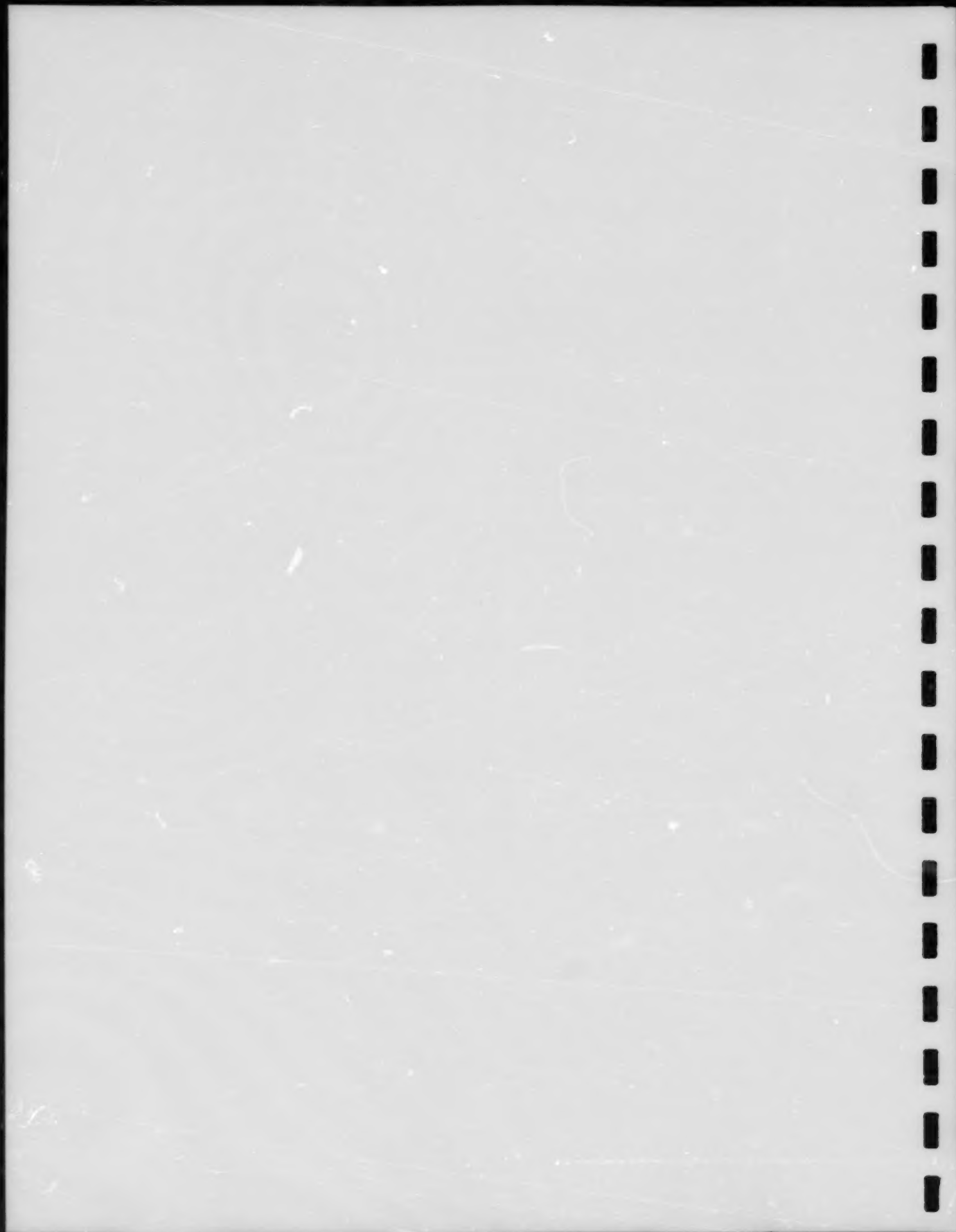
The Jubilee Stock intrudes the supracrustal rocks. This stock varies from diorite to a dominantly granodiorite composition. The stock contains abundant xenoliths and blocks of volcanic rock and is exposed at a high structural level.

The structural geology is complex. The structure of the rocks in McMurray Township is largely unknown due to the lack of bedding and facing data. The metavolcanic and metasedimentary rocks, north of Wawa Lake and extending northwest through Chabanel and Esquega Townships face north and are vertical to slightly overturned. The metavolcanic rocks in the northwestern part of Chabanel Township strike southeast, face southwest, and are recumbant. Overturning locally produces dips as low as 40° NW. A possible anticlinal structure occurs northeast of the McLeod Mine. Strike-slip faulting occurs along Wawa Lake, Talbot Lake, and the Magpie River. A younger northwest-trending set of left-lateral faults cut the fold axes and strike-slip faults. These northwest-trending faults are commonly occupied by diabase dikes. The Firesand River Carbonatite of Proterozoic age underlies the northeast corner at McMurray Township and northwest corner of Lastheels Township.

Carbonate alteration is pervasive in the supracrustal rocks north of Wawa Lake and in the northwestern one third of Esquega Township. Chloritoid alteration is found below and above the iron formation capping first cycle volcanism. The chloritoid likely formed as a result of regional metamorphism superimposed on previously altered metavolcanic rocks.

The supracrustal rocks have been metamorphosed to the greenschist rank of regional metamorphism. As the external greenstone-granite contact is approached the rocks were metamorphosed to the upper greenschist facies rank and locally to the lower amphibolite rank.

The iron formation has been a major source of iron and has been mined since 1900. Large volumes of siderite remain in the iron formation. Several former producing gold mines occur in McMurray



Township and numerous gold showings are present in Esquega Township. Active gold mining has not taken place in recent years, however, recent exploration activity for gold has been intense.

Geology of Chabanel, Esquega, Lastheels and McMurray Townships

District of Algoma

by

R.P. Sage¹

¹Geologist, Precambrian Geoscience Section, Ontario Geological Survey

INTRODUCTION

This report detailing the geology of Chabanel, Esquega, Lastheels and McMurray townships is the first of a series of reports dealing with the geology, structure and ore deposits of the Wawa area. The area has been subjected to intense mineral exploration several times in the past. Exploration for gold was intense around 1900, during the 1930's and at the present time. Iron was the subject of intense activity around 1900, during WWII, during the early 1950's and during the mid-1960's. Base metals have been the target of numerous exploration programs from the late 1950's to the mid-1970's. As a result of this exploration activity, a large volume of data has accumulated concerning the mineral potential of the area. In spite of the large volume of data available, records are missing for numerous exploration efforts and the records for most early work in the area have disappeared. Only brief summaries of the work are presented here. The reader should refer to the Assessment Files Research Office for the details regarding the properties discussed in this report.

The geology of the area has been discussed in numerous government reports which are available for study at the Mines Library, Ontario Geological Survey, Toronto.

In response to the voluminous literature available about the map area, this report contains a summation of past work in addition to recent observations. An extensive summary of this past work will not be included in subsequent reports.

This report was prepared in 1984 and 1985 with the selective addition of data in 1986 and may not represent the current thinking on several topics. Subsequent to the field work and report preparation, the Michipicoten supracrustal belt has had several regional geophysical and remote sensing surveys completed.

ACKNOWLEDGEMENTS

Many individuals have contributed to the Wawa mapping program. In 1979, E. Sawitsky, senior assistant aided the author in mapping. Mr. P. Leeselleur, Mr. E. Sagle and Ms. J. Turner were junior assistants on the mapping project. In 1980, Z. Rebic, senior assistant aided the author in mapping. Junior assistants, S. Abercrombie, D. MacMillian, T. Calvert and K. Neale performed mapping duties through July and August. During 1981, additional mapping was completed by Mr. D. England, T. Calvert and J. Inasi senior assistants. During July and August Mr. R. Worona, G. Oudkerk, R. Reid and Ms. K. Kosciusko performed mapping duties.

Mr. J. Huddart former exploration manager for the Algoma Steel Corporation assisted the project by making available exploration data. Mr. E. Berdusco, Mine Geologist for

Algoma Ore Properties has greatly helped the project by making available records covering mining operations in the Helen Iron Formation and exploration records for the Wawa area.

Mr. J. Schreiber, Fire Control Supervisor, aided the project by making available to the survey aircraft under charter to the Ministry of Natural Resources. Mr. E. Frey, District Geologist has aided the project by providing liaison with district Ministry of Natural Resources staff and local exploration companies working in the area. Numerous staff of the Wawa District, Ministry of Natural Resources have provided support to the mapping project. During the mapping program, numerous junior rangers from the junior ranger camps within the district assisted the crew in the mapping program.

Former Ministry of Natural Resources District Managers Mr. R. Alton, Mr. W. Straight and Mr. G. Murphy assisted and supported the project. This support continues under the direction of Mr. C. Clark, District Manager, Wawa District.

Numerous individuals within the exploration industry have made available data for various mineral showing in the area. These individuals are cited in the 'Description of Properties' section in this report.

Mr. N. Trowell, Subsection Chief, provided technical editorial comment and support.

LOCATION AND ACCESS

Chabanel, Esquega, Lastheels and McMurray townships are located between 84°31' and 84°48'W Long. and 47°56'00" and 48°06'30"N Lat (Figure 1). The surface area is approximately 373 km². The Trans-Canada Highway passes immediately west of the map area. Highway 101 passes through the northern part of McMurray Township and continues eastward through parts of Esquega, Lastheels and Chabanel Townships. A branch road from Highway 101 leads to the town of Hawk Junction. A rough road leads north from the sinter plant, MacLeod Mine, in Wawa Township to the abandoned power dam at Steep Hill Falls in central Chabanel Township (Plate 1). A rough private mine access road goes north from Highway 101 from the eastern end of Wawa Lake. This road is situated along the Chabanel-Esquega Township boundary and extends almost to the northern boundary of these two townships. A rough mine access road leads west from Hawk Junction to the former Regnery Mine site in north-central Esquega Township. A gravel road leads south from Highway 101 to the High Falls road along the Michipicoten River. This road passes through central McMurray Township and provides access to the principal gold properties in this township. A former logging road is present along the west side of the Firesand River but serves only as a footpath south of Megit Lake. Numerous unmarked and unmapped trails exist in McMurray and Esquega townships.

A new power access road was completed in 1990 from Highway 17 to Steep Hill Falls on the Magpie River, permitting access to northwestern Chabanel Township.

Most of the iron ranges are owned or under the control of the Algoma Ore Properties Ltd. The major and some of the minor gold properties are covered by patented claims some of which go back to 1900. Esquega Township is controlled by the Algoma Central Railway and is part of land grant given to the company in 1900 to stimulate railroad building. The Algoma Central Railroad took possession of its land grant between 1913 and 1918.

PHYSIOGRAPHY

The area around Wawa is one of rugged topography. The highest point above sea level within the present map area occurs on the Helen Iron Range north of the town of Wawa. A hill on the iron range has an elevation of 525 m above sea level. Within the map area, the relief is approximately 213 m. The relief is characterized by abundant outcrop, deep ravines, cliff faces and numerous intervening lakes and swamps.

McMurray and Esquega townships have been repeatedly logged and at various times subjected to brush fires. These two townships are covered by thick brush making traversing and outcrop location difficult. The area north of the MacLeod Mine is free of brush cover and provides an excellent opportunity to examine the geology of the area (Plate 2a). The very rugged terrain, abundant outcrop and thick bush cover make mapping a time-consuming physically strenuous exercise.

FIELD PROCEDURES

Mapping was done at a scale of 1:15 840. Published airborne geophysical government maps and various detailed geological sketch maps from the Assessment Files Research Office, Toronto were consulted during correlation and interpretations of the plotted data.

The preliminary maps were modified according to the thin section observations.

The property descriptions are dominantly compiled from the Assessment Files Research Office, Toronto with some modification resulting from brief visits conducted during this project. Underground workings at the former gold mines in the map area are inaccessible and a great deal of reliance has been placed on observations given in older reports.

The southeastern portion of Lastheels Township was mapped using helicopter supported reconnaissance techniques. The flat aeromagnetic pattern (ODM-GSC 1963a, 1963b) of the area combined with existing geological data indicated the presence of granitic

rocks of more limited economic interest than the supracrustal rocks. Mapping was concentrated in the supracrustal rocks.

PREVIOUS WORK

The earliest major contribution to the study of the regional geology of the area was by Collins and Quirke (1926) of the Geological Survey of Canada. The Ontario Geological Survey has published a number of reports on the area. The major studies are those of Parsons (1915), Gledhill (1927), Moore (1931), Froberg (1935), Bruce (1940) and Moore and Armstrong (1946).

Since 1960, A.M. Goodwin, University of Toronto has authored or co-authored numerous papers on the geology of the Wawa area. Dr. A. Turek, University of Windsor, has recently undertaken a uranium-lead geochronological study of the Wawa supracrustal rocks and associated plutons in partnership with other workers.

During the present study, the author has obtained numerous unpublished theses on various geological topics in the Wawa area. Copies of these documents are now available for examination at the Ontario Geological Survey Library, Toronto.

The author has consulted the previous work by Rupert (1975, 1979) on McMurray Township and found it to be of considerable help.

McGill and Shradly (1986) have conducted detailed structural studies in south central Chabanel Township.



LOCATION MAP

Scale: 1: 1 584 000 or
1 inch to 25 miles

GENERAL GEOLOGY

The four townships discussed in this report are underlain dominantly by suites of rocks of metavolcanic, metasedimentary and plutonic origin of Archean age.

The metavolcanic rocks of intermediate to mafic composition are dominantly massive and pillowed. Subordinate amounts of mafic tuff and breccia are locally present. Metavolcanic rocks range from tholeiite to high-iron tholeiite in composition. Basaltic komatiites are present in central Esquega Township.

The intermediate to felsic metavolcanic rocks display a wide variety of textural features but are relatively homogeneous in composition. These rocks are dominantly rhyolite, with subordinate dacite. There is a lack of metavolcanic rocks of intermediate composition and the volcanic sequence is strongly bimodal. The locally distributed, intermediate composition Jubilee Tuffs are reworked, so their compositions do not represent magma compositions.

The intermediate to felsic metavolcanic rocks are represented by quartz-feldspar porphyry flows, massive flows, quartz-feldspar crystal tuffs, feldspar crystal tuffs, tuff, lapilli tuff, oligomictic and polymictic breccia and spherulitic flows. The coarsest breccias occur below the Helen Iron Range. The thick intermediate to felsic metavolcanic section at this location and the numerous coarse breccias within the sequence suggest that this area was proximal to an Archean volcanic vent. Uranium-lead isotope ages indicate that the intermediate to felsic metavolcanic rocks below the Helen Iron Range dated at 2749 ± 2 Ma. (Turek et al. 1982) are essentially coeval with the Jubilee Stock dated at 2745 ± 3 Ma. (Sullivan et al. 1985). The Jubilee Stock may therefore be the subvolcanic equivalent to this sequence of intermediate to felsic metavolcanic rocks.

A minor, discontinuous band of northeast striking intermediate to felsic metavolcanic rocks extends from the Judith Iron Range in the northeastern corner of McMurray Township to the Kathleen Iron Range in the northeastern corner of Esquega Township. This unit consists of tuff, quartz-feldspar crystal tuffs, lapilli tuff and breccia.

North of the Magpie River a large area is underlain by tuff, lapilli tuff and coarse breccia of intermediate to felsic composition. This intermediate to felsic metavolcanic unit is the youngest recognizable Archean supracrustal unit. Turek et al (1982, 1984) reported uranium-lead isotopic ages of 2696 ± 2 my and 2698 ± 11 for this unit. Metasedimentary rocks consisting of conglomerate, wacke, siltstone and argillite are gradational into and interfinger with the intermediate to felsic metavolcanic rocks found north of the Magpie River and are dominantly derived by erosion of the intermediate to felsic metavolcanic rocks. The metasedimentary rocks north of and immediately east of the Magpie River are thinly bedded.

They display graded bedding, slump structures, mud-chip breccias and flame structures. They represent relatively deep water sedimentation.

The metasedimentary rocks in the Arliss Lake area and north of the Lucy Iron Range display limited grain gradation. They are commonly cross-bedded and display rare examples of ripple marks and mudcracks indicating they were likely deposited in a shallow water to subaerial environment.

Chert, pyrite and minor siderite iron formation occurs at the stratigraphic top of the discontinuous horizon of intermediate to felsic metavolcanic rocks that extends from the northeast corner of McMurray Township to the northwest corner of Esquega Township. In McMurray Township, this iron formation is known as the Judith Iron Range, in Esquega Township as the Kathleen Iron Range. This iron formation caps a subcycle of volcanism within first cycle volcanic rocks. A complete volcanic cycle is used herein to indicate a lower intermediate to mafic metavolcanic and an upper intermediate to felsic volcanic pair. A major iron formation unit caps first cycle volcanism and from west to east the fault bounded segments of this range are respectively the Mildred, Helen, Johnson, Eleanor, Lucy and Ruth Iron Ranges. This iron formation is characterized by a systematic sequence of iron formation facies. From the stratigraphic bottom to the top this iron formation consists of siderite, iron sulphide, chert-magnetite, chert-wacke and graphite-pyrrhotite-argillite. The various facies are gradational into each other but the upper and lower contacts of the iron formation are sharp. This iron formation caps the first complete cycle of volcanism and is overlain by intermediate to mafic metavolcanic rocks of cycle two. This iron formation unit has produced all the iron ore mined within these four townships.

The centre of cycle two volcanic rocks is represented by the intermediate to felsic metavolcanic rocks north of the Magpie River. Iron formation is not associated with intermediate to felsic metavolcanic rocks of this cycle. Mapping by the author north of the area suggests that an intermediate to mafic metavolcanic sequence may cap or interdigitate with the upper portion of this second cycle of intermediate to felsic volcanism or a structurally repeated stratigraphy. This massive to pillowed intermediate to mafic sequence may represent part of a third cycle of volcanism.

Numerous mafic intrusions intrude first cycle metavolcanic rocks and to a lesser extent second cycle metavolcanic rocks. These intrusions consist of quartz diorite, diorite and gabbro. These intrusions are best represented by the Reed Lake Stock in McMurray Township and the thick dominantly sill-like bodies that intrude first cycle intermediate to felsic metavolcanic rocks below the Helen, Johnson, Eleanor, Lucy and Ruth Iron Ranges.

A peridotite body containing Cu-Ni-Pt mineralization occurs at Sunrise Lake in Esquega Township. The long axis of this body is approximately normal to bedding of the existing metavolcanic rocks and prior to folding may have had a dike-like form.

Small peridotite bodies occur on Lena Lake, Mildred Lake and Bauldry Lake. These small intrusive bodies occur where the Magpie River Fault is cut by northwest-trending transverse faults.

Quartz-feldspar porphyry forms a partial ring around the Jubilee Stock. This quartz-feldspar porphyry may occupy a ring fracture associated with caldera formation at the time of emplacement of the Jubilee Stock.

Quartz-feldspar porphyry is an abundant rock type in Esquega Township. This porphyry is gradational into equigranular medium- to coarse-grained granodiorite of the Hawk Lake Granite. This granite has been isotopically dated as 2888 ± 2 my by Turek et al (1983, 1984). The quartz-feldspar porphyry intrusions in Esquega Township are not found stratigraphically above the intermediate to felsic metavolcanic rocks of subcycle one and thus may be the subvolcanic equivalent to these metavolcanic rocks.

Both olivine-bearing and olivine-free diabase dikes are common to the area. They commonly occupy northwest-trending faults and shear zones. Much less common are northeast-trending dikes. The dikes are sometimes porphyritic with large green plagioclase feldspar. They often pinch and swell considerably over short strike lengths.

The Proterozoic Firesand River Carbonatite underlies the northeast corner of McMurray Township and extends into Lastheels Township. This carbonatite has been isotopically dated by Gittins et al. (1967) as being 1008 and 1087 Ma in age. The carbonatite is zoned from a rauhaugite (dolomite) core to a sovite (calcite) rim and has been tested for its iron, niobium and phosphorous content. The carbonatite occurs at the intersection of the Wawa-Hawk Lake Fault with the Firesand River Fault. This carbonatite is equivalent in age to many carbonatites that occur along the Kapuskasing Structural Zone extending northeast from the Wawa area. Sage (1983a) describes the Firesand River Carbonatite in detail.

Within McMurray Township, carbonate alteration is commonly associated with shear and fault zones. The metavolcanic rocks are generally only moderately carbonated. North of Wawa Lake, throughout Chabanel Township and within the northwestern third of Esquega Township, the metavolcanic rocks, metasedimentary rocks and various intrusions are commonly pervasively soaked with rusty brown ankeritic carbonate. The pervasion carbonate alteration disappears as the margins of the greenstone belt are approached.

Chloritoid is a common mineral within the intermediate to felsic metavolcanic rocks and within the intermediate to mafic metavolcanic rocks situated respectively below and

above the Helen Iron Range. The chloritoid zone is broadly conformable to stratigraphy and is not a pipe-like alteration zone.

Chloritoid is present at the Lucy Iron Range and occurs within cycle two intermediate to felsic metavolcanic rocks without associated iron formation in the northwest corner of Chabanel Township. The chloritoid-bearing areas represent areas where hydrothermal alteration by stratiform permeability controlled aquifers has occurred.

Syn- to post-deformational regional metamorphism produced the chloritoid porphyroblasts within altered rocks.

The rocks have been metamorphosed to the greenschist rank of regional metamorphism. The rank approaches upper greenschist or lower amphibolite rank as the greenstone-granite contact is approached. The presence of small biotite clots in the epiclastic Jubilee Tuffs enclosing the Jubilee Stock suggests that the rocks surrounding the stock are of upper greenschist rank, perhaps the result of contact metamorphism.

The structure of McMurray Township is largely unknown due to the absence of facing data. Those rocks, principally, the Jubilee Tuffs, that occur inside the arcuate ring of the quartz-feldspar porphyry intrusion in the vicinity of the Jubilee Stock dip away from the stock at moderate to steep angles. The rocks outside the quartz-feldspar porphyry intrusion strike northeast through Esquega Township where they curve around to strike east. This sequence of rocks faces northwest and dips vertical or is slightly overturned to the south. North of the Helen Iron Range this northwest-facing sequence terminates against the Talbot Lake Fault. In the Arliss Lake area and north of the Lucy and Ruth Iron Ranges, the north-facing sequence terminates against the Magpie River Fault.

In the northwestern part of Chabanel Township, the metavolcanic and metasedimentary rocks strike southeast, dip northeast and young to the southwest. In the area southeast of Steep Hill Falls, dips as low as 40° are present and the section is recumbent. The southeast-striking recumbent rocks terminate against the Magpie River Fault. They represent the overturned south limb of the Centre Anticline of Goodwin (1962).

An anticlinal structure within cycle one intermediate to felsic metavolcanic is wedged between the Talbot Lake and Magpie River Faults northwest of the Helen Iron Range in Chabanel Township.

The oldest recognizable faults are dominantly strike-slip or possible thrust faults that trend parallel or slightly oblique to lithologic trends. This system of faults is represented by the Wawa-Hawk Lake, Talbot Lake and Magpie River Faults. The Wawa-Hawk Lake Fault is one of the many faults associated with the Kapuskasing Structural Zone and likely has its roots in the upper mantle since it has exerted control on the emplacement of the Firesand River Carbonatite.

The folded and faulted rocks are cut by a series of northwest-trending left-lateral transverse faults. Offset of several kilometres occurs along their southern extension within the map area, but the amount of offset decreases to the north. These faults are commonly occupied by diabase dikes.

Mafic intrusions referred to as "old diabase" by Frohberg (1935) and Gledhill (1927) are common in McMurray Township. These intrusions are similar to all other Archean mafic intrusions in the area and are considered to be Archean by the author. These "old diabases" have a pronounced northwest trend suggesting that the northwest faulting and shearing common to the Wawa area has its origin in Archean Tectonic activity. Later diabase, possibly Keweenawan in age, commonly occupies these Archean fractures and faults. These relatively young dike rocks locally display brecciation and offset indicating that a younger deformation event of unknown age has occurred.

Table 1 lists the lithological units present in the map area and Figure 2 illustrates the relationship of the various stratigraphic units.

EXTERNAL GRANITIC ROCKS (MAP UNIT 1)

External granitic rocks occur in the southeastern part of Esquega Township and throughout most of Lastheels Township. In general, the granitic rocks are poorly exposed and the relationship of the granitic rocks to the supracrustal rocks is not well defined. Local sharp contacts and the presence of linear topographic features at the contacts imply fault contacts while the presence of supracrustal rock xenoliths within the granites suggest intrusive relationships.

HAWK LAKE MIGMATITE COMPLEX

Extending south of Hawk Lake and the Hawk Lake Fault to the area south of the Dill River, a broad zone of mixed rocks strikes northeast. The zone is approximately 5.5 km wide and consists of a mixture of trondhjemite, tonalite, diorite and supracrustal blocks which have been intruded by younger more potassium-rich granitic pegmatites and aplites. Both the older granitic suite sodium-rich, potassium-poor and the younger potassium-rich granitic suite are found throughout the Canadian shield area. Such a sequence of granitic rock development has been observed by Thurston et al. (1977) and by the author in the Ignace-Armstrong area of Ontario (Sage, unpublished data, 1973).

The Aldo Palma molybdenite showing in the west-central part of Lastheels Township lies in proximity to the southern contact of this migmatitic terrain and a broad area

underlain by more potassium-rich massive equigranular granitic rocks referred to as the Whitefish Lake Batholith (Massey 1985). The contact between the supracrustal rocks and the granitic rocks in Lastheels Township is poorly defined. Traversing in proximity to the contact indicates rapid alternation between intrusive granitic rocks and supracrustal rocks. The contact in this region appears to be intrusive and is placed at the position where granitic rock exceeds 50% of the outcrop.

One sample of what is interpreted to be the oldest granitic phase was collected from a railroad cut south of Hawk Junction and examined in thin section. The rock is gneissic and displays podiform quartz and plagioclase on the outcrop surface. In thin section, the texture is medium-grained, equigranular, massive, hypidiomorphic. The mode is estimated as 25 to 30% quartz, 55% plagioclase, 10% sericite, 10% pyroxene and 5% biotite. Trace to minor quantities of chlorite, zircon and opaques, are present.

Quartz is present as anhedral, interlocking, interstitial, granoblastic aggregates with straight grain boundaries.

The plagioclase is anhedral to subhedral in outline and heavily saussuritized. The feldspar composition could not be optically determined.

The scattered sericite grains occur as tiny subhedral flakes, generally after plagioclase.

The clinopyroxene forms anhedral to subhedral interstitial grains that are ragged in appearance. The clinopyroxene is altered to chlorite and biotite. The intergranular nature of the pyroxene suggests that some pyroxene may be xenocrystic in nature.

Biotite is present as small anhedral ragged grains after pyroxene which may display minor chlorite alteration.

The rock sampled is a tonalite and was collected from a homogeneous appearing outcrop. The sample has been isotopically dated by U-Pb techniques by (Turek et al. 1982, p.1608) as 2747 ± 7 Ma. Turek et al. (1982) reported that the rock contains components of an older phase. The abundance of supracrustal xenoliths in this migmatitic terrain are the likely source for this older component.

Along Highway 101, south of the junction with the access highway to Hawk Junction, the outcrops consist of large blocks of supracrustal rocks enclosed within at least two ages of tonalitic to trondhjemitic granitic rocks. Dikes of massive pegmatite and aplite related to the younger potassium-rich granitic event sharply crosscut the supracrustal blocks and the older potassium-poor granitic rocks. Excluding the large volume of supracrustal material the granitic rocks of the migmatite terrain are composed of an estimated 30 to 40% early tonalite to trondhjemite that is in turn cut by a later trondhjemite phase comprising 30 to 60% of the outcrop area. The later potassium-rich phase may form up to 10% of the outcrop area. The gneissic supracrustal and early potassium-poor granitic phases contrast

texturally and structurally with the massive, non-foliated potassium-rich phases north and south of the migmatitic area, implying that the younger granites are posttectonic.

At the Aldo Palma molybdenite showing, the supracrustal xenoliths are not as large or as abundant and the granitic rocks are less gneissic than the rocks along Highway 101. There are at least two ages of trondhjemite emplacement and at least one period of later potassium-rich granitic diking. The trondhjemites at the Aldo Palma showing are much pinker in colour than those along Highway 101 and this may be due to a weak hematitization. Tourmaline was also noted along several fractures in the trondhjemite. Two samples of the trondhjemite from the Aldo Palma molybdenite showing were examined in thin section. The texture is medium-grained, equigranular, massive, allotriomorphic with curved to straight grain boundaries. The mode is estimated as 0 to 10% microcline, 40 to 50% plagioclase, trace to 10% biotite and 20 to 35% quartz. Epidote, opaques, carbonate, apatite, zircon and sericite are common minor mineral components. The microcline is anhedral, interstitial and fresh.

Plagioclase is present as anhedral to subhedral, tabular, moderately saussuritized grains. The plagioclase composition is approximately An₃₂ to An₃₇. In one sample, the alteration is cleavage controlled and some fracturing across the albite twin planes was observed. In one sample, sericite after plagioclase forms approximately 25% of the sample.

The biotite occurs as anhedral tabular grains.

Quartz is present as polycrystalline, interlocking, anhedral grains with straight to curved grain boundaries. The quartz appears to be unstressed.

An AFM plot (Figure 3) indicates the granitic rocks are calc-alkalic in composition and a cation plot (Figure 4) of the chemistry indicates all fall into the rhyolite field. A plot of normative mineralogy on a Streckeisen modal diagram (Figure 5) indicates the external granites are granite to granodiorite in composition. The Streckeisen classification indicates a more evolved granitic rock assemblage than indicated by petrography. Samples 1 through 6 are trondhjemites collected from the proximity of the Aldo Palma molybdenite showing, samples 7 and 8 are from the massive granodiorite to quartz monzonite terrain of the Whitefish Lake Batholith south of the migmatitic area and sample 9 represents a trondhjemite from the second intrusive phase of the earlier potassium-poor granitic intrusive event.

As a group, the chemistry of the external granitic rocks display considerably more scatter and a less evolved chemistry than the massive medium- to coarse-grained rocks of the Hawk Lake Granitic Complex.

WHITEFISH LAKE BATHOLITH

The area south of the migmatitic terrain is underlain by a large expanse of massive medium-grained granodiorite to quartz monzonite. The area is characterized by a relatively flat magnetic pattern (ODM-GSC 1963a, 1963b) and there is little indication of the presence of supracrustal blocks or xenoliths. The potassium-rich phases cutting the Hawk Lake Migmatite Complex are probably related to this batholithic body of relatively homogeneous granitic rock.

In the Mishewawa area, adjoining Lastheels Township to the south, Massey (1985) described the contact zone with the Whitefish Lake Batholith as being up to 1.5 km in width. This contact zone contains supracrustal enclaves and is veined with fine-grained aplite and medium-grained granodiorite. Massey (1985) reported the presence of porphyritic phases, however, these phases were not observed by the author.

One sample of this medium-grained massive granitic rock collected from outcrop along Highway 101 south of the migmatitic terrain was thin sectioned. A sample from the same outcrop has also been isotopically dated by Turek et al. (1984) as being 2694 ± 3 Ma.

In thin section, the rock is medium-grained, equigranular, massive and hypidiomorphic in texture. The presence of protoclastic textures has been reported by Massey (1985).

The rock consists of an estimated 10 to 15% microcline, 50 to 55% plagioclase, 8 to 10% biotite and 25 to 30% quartz. Trace to minor amounts of epidote, sericite and granophyre were observed.

The microcline occurs as fresh anhedral, interstitial grains that partially enclose plagioclase.

The plagioclase is approximately An₃₈ in composition and occurs as anhedral to subhedral interlocking crystals. The plagioclase displays heavily saussuritized cores, moderately saussuritized rims and may display a very narrow clear rim of untwinned feldspar. Massey (1985) reported epidote as part of the alteration assemblage.

Biotite is present as tabular ragged anhedral intergranular grains that have undergone some alteration to chlorite.

Quartz is present as anhedral interlocking interstitial grains that usually display wavy extinction.

Massey (1985) observed myrmekitic and graphic overgrowths on some plagioclase grains from the granodiorite to quartz monzonite suite south of the migmatite terrain. Granitic rock compositions representing the Whitefish Lake Batholith are plotted on Figures 3, 4 and 5. The samples plot in the calc-alkalic field.

INTERMEDIATE TO MAFIC METAVOLCANIC ROCKS (MAP UNIT 2)

Intermediate (andesite) to mafic metavolcanic rocks (basalt) are the dominant metavolcanic rocks within the Wawa supracrustal sequence. Within the map area, there are two and possible three cycles of intermediate to mafic volcanism. The first cycle lies between the external granitic rocks in the southeastern portion of Lastheels Township and the main Michipicoten Iron Formation. The first cycle of volcanism represents a complete mafic to felsic cycle with one complete internal mafic to felsic subcycle occurring within the lower portion of cycle one. The second cycle of intermediate to mafic volcanism overlies the Michipicoten Iron Formation and is in turn overlain by clastic metasedimentary rocks derived by erosion of second cycle felsic metavolcanic rocks. In Musquash and Leclaire townships, north of the map area, the clastic metasedimentary rocks are overlain by a possible third cycle of intermediate to mafic metavolcanic rocks or represents a structurally repeated stratigraphy.

Regardless of which cycle one is working with all display similar lithologic and textural features. Subcycle one of the first cycle intermediate to mafic metavolcanic rocks display the development of komatiite lavas at the base of the section in Esquega Township. First cycle volcanism is represented by a high iron to magnesium tholeiitic flow sequence. These high iron to magnesium tholeiites offer an excellent source for both the iron and silica that form the Michipicoten Iron Formation capping the first cycle. The high iron compositions of the first cycle metavolcanic rocks may in part account for the fact that Michipicoten Iron Formation was developed after first cycle volcanism in response to hydrothermal activity.

The first, second, and possible third cycles are closely equivalent to Goodwin's (1962) lower, middle, and upper volcanic rocks.

SUBCYCLE ONE: INTERMEDIATE TO MAFIC METAVOLCANIC ROCKS

Mafic to ultramafic metavolcanic rocks consisting of actinolite plus chlorite are present on the former Lakemount Mines Limited Property (see PROPERTY DESCRIPTIONS) in Esquega Township but rare in other parts of the map area. One outcrop of spinifex textured rock was located north of the former Lakemount Mines Property. On a cation Plot, (Figure 6) the spinifex textured rock plots as an ultramafic komatiite. Several outcrops of polysutured were located in the area between the former Lakemount Mines Limited property and McEwen Lake (Plates 2b, 2c). Two samples of these rocks were analyzed and found to plot in the basaltic komatiite field on a cation plot (Figure 6).

The mafic metavolcanic section between McEwen Lake and the Hawk Lake Granitic Complex contains the only mafic to ultramafic metavolcanic rocks so far recognized in the Wawa area as being komatiitic in composition.

The mafic to ultramafic rocks of Subcycle one extend from the base of the Judith Iron Range in McMurray Township to the base of the Kathleen Iron Range in Esquega Township. Rocks of strong komatiitic affinity that characterize subcycle one have not been identified in other parts of the Wawa supracrustal sequence. The lower part of this subcycle is intruded by rocks of the Hawk Lake Granite Complex isotopically dated as 2888 ± 2 Ma by Turek et al. (1983, p.470 1984, p.457). This subcycle may have once been far more extensive in distribution, and has been subsequently destroyed by tectonism and granitic intrusion. Subcycle one is possibly a small remnant of a much larger early cycle of volcanism that formed the base to cycle one volcanism. This early cycle was not recognized by Goodwin (1962).

CYCLE ONE INTERMEDIATE TO MAFIC METAVOLCANIC ROCKS

By far, the two dominant mafic rock types of cycle one are massive and pillowed mafic metavolcanic rocks. Excellent exposures of pillowed and massive mafic metavolcanic rocks occur along Highway 101 east of Wawa. The pillow structures are up to 1 m in size and this size range characterizes cycle one pillowed flows. The pillow selvages vary from 1 to 8 cm in width and consist of fine-grained chlorite. Several outcrops along Highway 101 display hyaloclastite tuff interpillow fillings. Amygdules in the pillow rims appear to increase in number and size as one moves up stratigraphy. At the top of the section below the intermediate to felsic metavolcanic rocks of cycle one, almond-shaped amygdules exceed 1 cm in size and may compose up to 20% of the rim area of the pillow. Such large amygdale size and volume indicate low confining pressure and perhaps shallow water (Moore 1965). The stratigraphy suggests that the basin of deposition may have decreased in depth as volcanism proceeded.

Within the first cycle mafic metavolcanic rocks, it is not uncommon to find flows with euhedral magnetite crystals indicative of the high iron content of these flows. These crystals are generally on the order of 1 mm in size but crystals up to 8 mm occur in pillowed mafic metavolcanic rocks at the east end of Wawa Lake. Such magnetite-bearing flows would make good geophysical markers. Minor euhedral pyrite may also occur in the magnetite-bearing flows.

Lapilli tuffs and laminated tuffs are not common but are present between the massive to pillowed flow units. In the vicinity of Loonskin Lake, some feldspar crystal tuffs are

present which consist of subhedral buff-weathering feldspar phenoclasts in a chlorite schist matrix. In the feldspar crystal tuffs, the feldspars may be as large as 8 mm and compose up to 30% of the rock. In the same area and lying above, the Kathleen Iron Range capping subcycle one is a tuffaceous unit that consists of scattered pale blue quartz grains in chlorite schist. The quartz grains within the quartz-bearing tuffs are 1 mm or less in diameter and do not compose much more than 1 or 2% of the rock.

Outcrops interpreted as feldspar-phyric flows, or amphibole-phyric flows are uncommon. The feldspar-phyric flow rocks are massive and difficult to distinguish from the feldspar tuffs. The flows with mafic phenocrysts are massive with chlorite-replaced phenocrysts up to 4 to 5 mm.

Variolitic mafic metavolcanic rocks are rare in the Wawa supracrustal rocks even though Massey (1985) reported variolitic flows to be common in the greenstone belt south of Wawa in what are interpreted to be equivalent to cycle one metavolcanic rocks. One outcrop of pillowed mafic metavolcanic rocks in a road cut at the east end of Wawa Lake displays varioles up to several millimetres in diameter in the marginal part of the pillows. The varioles become larger and coalesce towards the pillow core. Individual varioles are no longer recognizable in the core of the pillow. Variolitic flows were also encountered on the shore of Loonskin Lake.

A polymictic breccia occurs at the top of the mafic metavolcanic portion of the first cycle volcanic rocks. This unit is up to 100 m in width, heavily carbonated and forms a distinctive marker horizon separating the mafic and felsic parts of first cycle volcanism. This unit has been traced from the Lucy Iron Range to the east end of the Josephine-Bartlett Iron Range in Corbiere Township a distance of 13 km. The best exposure of this breccia occurs on the southwestern shore of Brooks Lake below the Lucy Iron Range and good exposures are present on the south side of Parks Lake below the Josephine Iron Range, Corbiere Township.

At the Lucy Iron Range, the breccia varies considerably in clast size across section and may actually be a series of at least three breccia units. The clasts are up to 30 cm in maximum size, subangular to subrounded in outline, grey weathering and dominantly of intermediate composition. The clasts are amygdaloidal and commonly enveloped in an accretionary rim of black mafic tuff that composes the matrix. The accretionary rim may approach 1 cm in width. A narrow bleached reaction rim up to 1 to 2 mm in width may occur on the rim of the clasts but not on the accretionary rim. The unit is poorly sorted, matrix-supported and weathers with a jagged rough surface. The grey clasts weather high above the black to green black carbonated matrix. Rare, angular grey chert clasts are locally present.

Midway through the section of breccia on the southwestern shore of Brooks Lake, a narrow irregular breccia dike approximately 15 cm wide cuts the mafic breccia and may represent a local degassing phenomena developed at the time of emplacement.

On the south side of Parks Lake, below the Josephine Iron Range the breccia unit is very heavily carbonated and no longer weathers with jagged relief. The unit appears more polymictic at the Josephine Iron Range relative to the Lucy Iron Range with both mafic and intermediate clast compositions being present. Fragments of sulphide and laminated chert most likely derived from a minor discontinuous band of iron formation that occurs below the volcanic breccia and above the pillowed and massive section are present in the breccia at the Josephine Iron Range. Reaction rims on fragments in both the Lucy and Josephine areas indicate that the polymictic breccia may have been warm at the time of emplacement. This distinctive breccia unit forms a marker horizon from the Lucy Iron Range eastward and is interpreted to represent one or several warm to hot lahars or debris flows emplaced at the onset of cycle one intermediate to felsic volcanism. The presence of this distinctive unit at the break between contrasting styles and composition of volcanism suggests an intimate relationship with this change. There is question as to whether this volcanic breccia represents the cessation of intermediate to mafic volcanism or and start of intermediate to felsic volcanism. The presence of chert fragments in the breccia suggests that a hiatus in time between breccia formation existed in which some chemical sedimentation occurred. Therefore, the author interprets the unit to mark the onset of intermediate to felsic volcanic activity.

Immediately below the Lucy Iron Range, capping the intermediate to felsic metavolcanic rocks of cycle one lies on a distinctive oligomictic, yellow brown weathering, highly altered breccia which is interpreted to have been originally mafic in composition. The breccia consists of subangular to subrounded fragments up to 0.3 m in size some of which are estimated to be composed of at least 50 volume % amygdules and is almost pumice. These amygdules are commonly 1 cm or greater in maximum dimension and are often filled with white to yellow brown carbonate. The amygdules are pipe-like in some clasts. These amygdules may be 2.0 cm or more in length and only a few millimetres in diameter. The occurrence of a mafic breccia immediately below the iron formation has not been observed in the other iron ranges.

An AFM (Figure 7) plot of chemistry from first cycle mafic metavolcanic rocks indicate a sequence that just straddles the boundary between tholeiitic and calc-alkalic compositions. A cation plot (Figure 6) indicates that the first cycle metavolcanic rocks are dominantly high magnesium to high iron tholeiites.

Figures 8 and 9 are AFM and cation plots of first cycle metavolcanic rocks below the Lucy Iron Range. Figure 10 is a cation plot of first and second cycle metavolcanic rocks below and above the iron formation. Comparing the data from the two cycles it appears that second cycle intermediate to mafic metavolcanic rocks fall more towards basalt and andesite in composition and do not display the strong iron and magnesium enrichment that characterizes the first cycle.

CYCLE TWO INTERMEDIATE TO MAFIC METAVOLCANIC ROCKS

Cycle two intermediate to mafic metavolcanic rocks lie above the Michipicoten Iron Formation and below a thick section of clastic metasedimentary rocks. The unit is almost exclusively massive to pillowed flows, with the occasional thin interflow felsic tuff, cherty iron formation, or fine-grained laminated argillite, siltstone or wacke. In the upper part of the section pillow breccia and mafic breccia are more common. Pillows up to 5 m in maximum dimension were noted west of Mildred Lake.

The pillows are commonly amygdaloidal throughout the stratigraphic section with almond-shaped amygdules up to 1 cm forming up to 15 to 20% of the outer part of the pillow. The amygdule size and quantity indicate relatively shallow water or low confining pressure at the time of extrusion (Moore 1965). Figures 11,12,13, and 14 are AFM and cation plots of cycle two metavolcanic rocks above the Lucy and Helen iron ranges. The Helen Iron Range metavolcanic rocks display a greater range in composition than do those of the Lucy Iron Range perhaps due to an unrecognized pattern of alteration. Figures 15 and 16 are respectively AFM and cation plots of all cycle two intermediate to mafic metavolcanic rocks. The cycle two metavolcanic rocks display a considerable range in composition from high iron to magnesium tholeiitic basalt and andesite. One basaltic komatiite occurs in the middle of the cycle above the Lucy Iron Range and this komatiite analysis is the only one encountered outside the area of subcycle one. Helen Iron Range cycle two intermediate to mafic metavolcanic rocks form an incomplete section since the Talbot Lake Fault cuts out the upper part of the section.

CYCLE THREE INTERMEDIATE TO MAFIC METAVOLCANIC ROCKS

Cycle three intermediate to mafic metavolcanic rocks occurs above the clastic metasedimentary rocks and are incompletely delineated. This possible cycle may represent structurally repeated cycle one or cycle two intermediate to mafic metavolcanic rocks. Mapping in Musquash and Leclaire townships north of the map area indicates that the cycle

three intermediate to mafic metavolcanic rocks are indistinguishable in the field from the cycle one and two intermediate to mafic metavolcanic rocks. The rocks are dominantly pillowed to massive with the occasional thin interflow intermediate to felsic tuff, cherty iron formation, or laminated argillite, siltstone, or wacke. Within the map area, the metavolcanic rocks of this cycle are recumbent and form part of the south limb of the Centre Anticline.

INTERMEDIATE TO FELSIC METAVOLCANIC ROCKS (MAP UNIT 3)

Within the limits of the map area, intermediate to felsic metavolcanic rocks are a major part of the supracrustal section. Most felsic metavolcanic rocks can be assigned to three broad groupings; the felsic metavolcanic rocks associated with the subcycle internal to the intermediate to mafic part of cycle one metavolcanic rocks, the felsic metavolcanic rocks forming the upper part of cycle one, and the felsic metavolcanic rocks associated with cycle two. Minor felsic metavolcanic material also occurs as thin interflow units in the mafic parts of all volcanic cycles. These narrow units are fine-grained, massive to thinly laminated and commonly cannot be traced laterally for any significant distance even where exposure is nearly total. The intermediate to felsic metavolcanic rocks will be discussed under the three groupings. The intermediate composition Jubilee Tuffs are discussed under a separate heading.

SUBCYCLE ONE: INTERMEDIATE TO FELSIC METAVOLCANIC ROCKS

The intermediate to felsic metavolcanic rocks of this subcycle form the and possibly to the Judith and Kathleen Iron Ranges, and possibly to the Holdsworth Pyrite Deposit (Corbiere Township, AFRO, Toronto) and are well-exposed on Holdsworth Lake, Esquewa Township.

North of the Firesand River Carbonatite, scattered outcrops of intermediate to felsic tuff, lapilli tuff and rare breccia are present. Some intermediate to mafic flows occur in the section as one moves north into the footwall rocks below the Judith Iron Range. Directly below the Judith Iron Range a massive quartz-feldspar porphyry unit, possibly a crystal tuff, that may be up to 100 m thick is present. The unit contains up to 3% quartz phenocrysts in seriate distribution up to 1 mm in diameter. The unit lacks primary textures and was interpreted by the author in the field to be a quartz porphyry flow, but in thin section contrasting domains of differing grain size imply a former fragmental nature.

At Holdsworth Lake, the intermediate to felsic metavolcanic rocks consist of quartz-feldspar crystal tuff, lapilli tuff and tuff. The rocks are schistose and generally lack primary

bedding. South of Holdsworth Lake and south of the mafic intrusion centered on Sunrise Lake, several outcrops of coarse polymictic breccia are present (Plate 3). The clasts are subangular to subrounded to rounded, up to 20 cm in diameter and represent a broad spectrum of volcanic rock compositions. The polymictic nature of these breccias suggests a debris flow origin.

Below the Kathleen Iron Range, the felsic metavolcanic rocks are dominantly quartz-feldspar crystal tuff, tuff and lapilli tuff. The units are narrow and interbedded with mafic metavolcanic rocks, dominantly tuff.

The units below the Kathleen Iron Range are schistose to very fissile. Outcrops along strike that are exposed along the tracks of the Algoma Central Railway line consist of oligomictic breccias in addition to the other rock types. Breccia is uncommon below the Kathleen Iron Range.

To the northeast, thin units of sericite schist occur below the Holdsworth Pyrite Deposit in Corbiere Township (Sage 1987b, 1987c). These schists are poorly exposed, fissile, carbonated and may contain a trace of pyrite.

The felsic metavolcanic rocks of subcycle one are difficult to correlate from area to area. The units are narrow and are interbedded with mafic metavolcanic rocks. As much as 2000 m of mafic metavolcanic rocks overlie the Judith Iron Range, however, at the Holdsworth Pyrite Deposit the mafic section above the iron formation is on the order of 500 m. The intermediate to mafic metavolcanic rocks above subcycle one thin rapidly from west to east. This could mean that the intermediate to mafic metavolcanic rocks were not deposited towards the east and/or that felsic volcanism migrated up the stratigraphic section from west to east. However, the present distribution of rock types and unit thickness may reflect tectonic rather than original depositional relations. The deformed and schistose nature of the rocks indicate considerable tectonic activity has taken place. The Judith, Kathleen and Holdsworth iron ranges may or may not be time equivalents but are interpreted to be equivalent due to similarity in volcanic stratigraphy. The iron ranges that cap this subcycle of volcanism have a sulphide facies base and cherty top. Siderite is absent from the Judith Iron Range but is reported to be present in the Kathleen Iron Range (AFRO, Toronto). The presence of siderite at the Kathleen Iron Range could not be confirmed by the author.

A thin section of the quartz-feldspar crystal tuff on Holdsworth Lake has a fine-grained, seriate, granoblastic texture with lobate grain boundaries. The mode is estimated as 25% quartz, 35% plagioclase (An₃₇), trace of chlorite and 40% fine-grained matrix. The quartz forms rounded to subangular grains with weak undulatory extinction. The plagioclase is present as fractured angular grains that are extensively saussuritized. The matrix is an

interlocking granoblastic mosaic of quartz and plagioclase with up to 10% sericite. The sericite imparts a schistosity to the rock.

Thin sections were prepared from the porphyritic rocks beneath the Judith Iron Range. The rocks are fine- to medium-grained, porphyritic-hyaline with a granoblastic matrix. The quartz phenocrysts generally occur in quantities of 1 to 5% and plagioclase phenocrysts are approximately 5%. Minor to trace amounts of carbonate, sphene, biotite, sericite and opaques are present. The quartz occurs as elongate to rounded polycrystalline grains with local cusped margins suggesting local resorption into the felsic magma. The internal grain boundaries of the polycrystalline quartz grains are lobate to straight. The plagioclase crystals are euhedral to subhedral in outline dusted with sericite and carbonate alteration and display traces of epidote alteration.

The matrix is composed of approximately 50% granoblastic mosaic of untwinned plagioclase and quartz and 50% fine-grained sericite that imparts a schistosity to the rock. The quartz and feldspar morphology and content are more typical of quartz-feldspar crystal tuffs. The flow unit is more likely a massive crystal tuff.

Figures 17 and 18 are AFM and cation plots of subcycle one intermediate to felsic metavolcanic rocks. The four samples shown on the above diagram were collected in the Holdsworth Lake area. They display a calc-alkalic nature and fall into the rhyolite field on a cation plot.

Figures 19 and 20 are AFM and cation plots of flow-banded quartz porphyry flow rocks in the Stanley Lake area (eight samples) and massive quartz-feldspar porphyry rocks below the Judith Iron Range (four samples). The flows are calc-alkalic and all plot in the rhyolite field on the cation plot. Since the Stanley Lake porphyritic rocks are very fresh, their chemistry maybe the closest approximation of a possible melt composition. Porphyritic clasts in cycle one and two intermediate to felsic metavolcanic rocks are very similar to the Stanley Lake porphyritic flows. The samples from below the Judith Iron Range (subcycle one) and those from Stanley Lake, in all probability, are from volcanic cycles of two different ages.

JUBILEE TUFFS

East of the Jubilee-Darwin Shear Zone and forming the eastern and southern flank of the Jubilee Stock is a series of reworked tuffs that cover a large area of McMurray Township. These tuffs consist of feldspar crystal-rich and crystal-poor types that on occasion display some bedding. These tuffs are usually massive and appear to dip away from and are conformable to the outline of the Jubilee Stock. Primary structures suitable to determine

facing directions are absent. The tuffs commonly have a criss-crossing pattern of ridge-like weathering that is distinctively different from other lithologies in the Wawa supracrustal rocks. This weathering pattern is most likely due to alteration along joint surfaces. A good photograph of this feature appears in Gledhill (1927, p.32). The author (Sage 1979) has interpreted the tuffs to be effusive products associated with the stock emplacement. Matheson (1932 p.34) also suggested that these rocks are related to intrusive granitic complexes but he did not report criteria to substantiate the correlation. The tuffs appear to dip at moderate angles away from the stock, lack penetrative deformation and have been previously interpreted to represent a fourth and latest cycle of Archean volcanism in the Wawa area (Sage 1979). The Jubilee Stock contains xenoliths of these tuffs and has been dated by U-Pb techniques at being 2745 ± 3 Ma. (Sullivan 1985). The tuffs are therefore, no younger than first cycle volcanism and may in some way be part of this cycle.

These feldspar-bearing reworked tuffs were considered to be plutonic by early investigators (Gledhill 1927; Matheson 1932, 1933), however, the author, Rupert (1979) and Studemeister, (1983 unpublished data) consider them to be reworked tuffs. Fragmental horizons exist in the sequence but in general could not be traced laterally. Fragments tend to be lapilli in size and the relatively uncommon breccias tend to be polymictic. In all cases, the fragments are matrix supported. In the area of Bond Lake and at several sites east of Bond Lake, a breccia with lapilli size clasts contains occasional round, reddish-brown, siliceous clasts. This clast type is distinctive in the field and its source is unknown. North of the Parkhill and Darwin mines, are polymictic breccias that occur along or in proximity to the contact with the Jubilee Stock. They form a marker horizon of limited extent that serves to determine offset along the Parkhill Fault. These northeast-striking breccias were referred to as agglomerate by Froberg (1935, p.42). The author and Studemeister (1983, personal communication) consider these breccias to be slump deposits or debris flows occupying paleo-depressions on the flanks of the volcanic structure that formed above the Jubilee Stock.

Rupert (1979, p.24) reported the presence of massive porphyritic lavas and pillow lavas within these tuffs. However, the author has not observed porphyritic units that could be clearly interpreted as flows, nor has he recognized pillow lavas in association with these intermediate composition rocks.

The grey to grey-green weathering of these intermediate rocks sets them apart from the usual yellow brown, yellow green, to buff coloured felsic rocks and the green to dark green mafic rocks. Rarely, small (1 to 2 mm), blue, opalescent quartz grains may be present and elliptical clots of fine-grained biotite up to 1 cm in long dimension are locally common. A sharp contrast between these tuffs and the supracrustal rocks in other parts of the area is their lack of good penetrative deformation, which results in their blocky appearance.

Gledhill (1927, p.18) interpreted these tuffs to be an irregular, flat, sill-like mass. The fact that these rocks have a similar appearance over long distances perhaps supports the hypothesis that one is looking at a very shallow-dipping oblique section. The possibility that the unit is shallow dipping as a result of recumbent folding as observed south of Steep Hill Falls, Chabanel Township has been considered by the author, but there is no geologic data supporting this interpretation. The recumbent section south of Steep Hill Falls has good schistosity and locally well-developed, fracture cleavage and isoclinal folds. The recumbent rocks at Steep Hill Falls display ample evidence of deformation while the intermediate composition tuffs near the Jubilee Stock commonly display little evidence of tectonic events. It is conceivable that an irregular angular unconformity may exist between these tuffs and underlying mafic and metavolcanic rocks of cycle one volcanism. A U-Pb isotopic age would help place the Jubilee Tuffs in their proper stratigraphic position.

The feldspar crystals within the feldspar-bearing tuffs may display a relict concentric zonation. The matrix consists of 15 to 30% biotite, 15 to 25% epidote, 0 to 25% amphibole, 0 to 10% carbonate, 0 to 5% chlorite and 0 to 5% sericite. The matrix also consists of a 20 to 40% fine-grained granoblastic mosaic of quartz and untwinned plagioclase. The presence of amphibole plus biotite and diminished quantities of chlorite indicate this rock is of upper greenschist rank, which contrasts with the usual greenschist rank found in the area. Gledhill (1927, p.11) reported observing biotite replacing hornblende and Matheson (1932, p.33) reported alteration of hornblende to chlorite in addition to biotite within these tuffs, implying a retrograde effect. It is likely that the tuffs close to the contact with the Jubilee Stock were subjected to contact metamorphism and later retrograded in a facies event. Gledhill (1927, p.11) reported the presence of zoisite and crushed quartz grains. Traces of opaques were observed by the author.

On the basis of field relations and the U-Pb isotopic age for the Jubilee Stock, these tuffs may occur at the interface between the mafic and felsic parts of cycle one volcanism. A thin unit of feldspar crystal tuff, similar to those found within the Jubilee tuffs occurs between the mafic and felsic parts of cycle one volcanism on the western side of Brooks Lake, Chabanel Township. This was the only site where tuffs of intermediate composition were observed at the mafic-felsic interface in the map area.

In the area east and south of the Jubilee Stock, these are the dominant rock units. This, in combination with their massive, non-schistose nature and moderate bedding dips, prompted the author (Sage 1979) to propose a link with the Jubilee Stock, a relationship that has not been clearly supported by subsequent rock chemistry and uranium-lead isotopic dating. Figures 21 and 22 present AFM and cation plots of the feldspar-free tuffs and Figures 23 and 24 present AFM and cation plots of the feldspar-rich tuffs. The feldspar-free

tuffs are more variable in composition than the feldspar-rich tuffs and range from high magnesium tholeiites to dacite in composition with most falling into the andesite field on a cation plot. *The feldspar-rich tuffs range from basalt to dacite in composition with most being andesite on a cation plot.* Comparison of the cation plots for the tuffs and the Jubilee Stock indicates the tuffs are much more primitive in composition than the stock and thus may be related to an earlier magmatic phase of the Jubilee Stock that is not now exposed. Analogous magmatic rocks may be present in the Reed Lake mafic intrusion which, the author interprets to be coeval with the Jubilee Stock. The Jubilee Tuffs have undergone limited reworking. The present rock compositions are therefore not likely to be approximations of a melt and their epiclastic nature accounts for their chemical variability. Figures 25 and 26 present, respectively, AFM and cation plots for all Jubilee Tuff samples.

In the Stanley Lake area, the Jubilee Tuffs are represented more frequently by polymictic breccias. The tuffs extend from the eastern contact of the Jubilee Stock to the north-striking quartz-feldspar porphyry unit that occurs as an outer, ring-like intrusion enclosing the stock. The breccias extend northward to the proximity of Highway 101 but are poorly represented in outcrops along the highway.

Close to the Jubilee Stock the polymictic breccias contain round to angular clasts up to 0.3 m. Bedding is locally well-developed, striking generally north direction and dipping at relative shallow angles to the east. The bedding varies from thin to medium in thickness and grain gradation was not observed. The bedding is oblique to the long axis of the lithologic unit suggesting that one is looking at an oblique cross section through a channel fill on the flanks of the Jubilee Stock. At the western extremity the breccia and tuffs are incorporated into the stock and the margins of the stock become an intrusive breccia (Plate 4). Good primary bedding can be observed in some of the xenolithic blocks within the intrusive breccia.

The breccia is matrix-supported and the clasts consist of fine-grained massive felsic metavolcanic rocks, feldspar porphyry and fine-grained mafic volcanic rocks. Feldspar porphyry forms the dominate clast type. Bleached reaction rims occur on some but not all of the fragments (Plate 5). Bedding within the fine-grained tuffs and crystal tuffs is better in the central and eastern extremities than close to the contact with Jubilee Stock.

Clast size diminishes from coarse breccia in the west near the contact with the Jubilee Stock to lapilli clasts towards the east. The matrix consists of fine-grained tuff, feldspar crystal tuff and very rarely quartz feldspar crystal tuff. Ribbed weathered surfaces are locally present and some joints display a red alteration. Minor fine-grained biotite is present in some samples.

The Jubilee Tuffs of the Stanley Lake area are separated from the Jubilee Tuffs east and southeast of the Jubilee Stock by a mass of flow banded quartz porphyry flows south of Stanley Lake. As with the breccias and tuffs of the Stanley Lake area, the quartz porphyry flows appear to occupy a channel within the metavolcanic rocks on the east side of the Jubilee Stock.

The bedding in the breccias tuffs and feldspar crystal tuffs at Stanley Lake is better development than that found in the Jubilee Tuffs from other areas. This feature, plus well-developed rounding on some of the clasts, has prompted some mappers to classify the Stanley Lake tuffs as metasedimentary rock (Rupert 1975). The author prefers to classify the tuffs as reflecting a volcanic parentage, but has no strong disagreement with a sedimentary terminology.

INTERMEDIATE TO FELSIC METAVOLCANIC ROCKS (CYCLE 1)

The intermediate to felsic metavolcanic rocks of cycle one form a distinct unit above the first cycle mafic metavolcanic rocks and they are capped by Michipicoten-type iron formation. The present stratigraphic section at the western end of this sequence now appears to exceed 2000 m in thickness, but this is due to sill-like intermediate to mafic intrusions which have expanded the section, making it appear thicker than it really is. At the eastern limit of this lithologic package, on Siderite Lake, in Corbiere Township (to the north of the map area), the intermediate to felsic metavolcanic section is on the order of 300 m in width. The intermediate to felsic lithologic package thins rapidly to the east. The great thickness of intermediate to felsic metavolcanic rocks beneath the Helen Iron Range indicate a proximal source for these rocks. In addition, very coarse breccias with angular clasts up to 1 m in size occur in the Helen Iron Range but are not common in the other sections. The growth of this section by extrusion and piling up of viscous lava at the Helen Iron Range formed an exogenous dome (Newhall and Melson 1983, p.123). The steeply overturned sequence provides a cross sectional view of the dome. In the stratigraphic section north of Wawa Lake, there is little, if any, preserved structural evidence that this felsic buildup occurred within a caldera-like structure characterized by ring fracturing, subsidence and resurgence. The lateral persistence of conformable post-volcanic alteration patterns imply that the aquifers controlling the movement of the altering fluids were not subjected to channeling or focussed flow that would have developed if ring fracturing and faulting associated with caldera structures had taken place.

A number of rock types occur in the section below the Helen Iron Range and west of the Jubilee-Darwin Shear Zone in McMurray Township. The section between Wawa Lake

and the Helen Iron Range is well exposed and is the type section for cycle one intermediate to felsic metavolcanic rocks. The rocks below the Helen Iron Range are present in equivalent sections below the Johnson, Eleanor, Lucy and Ruth iron ranges in Chabanel and Esquega townships and the Josephine-Bartlett Iron Range in Corbiere Township. The intermediate to felsic metavolcanic rocks located immediately northwest of the Helen Iron Range south of the Magpie River are cycle one intermediate to felsic metavolcanic rocks that have been folded and faulted above the iron formation. The top of the felsic metavolcanic section below the Helen Iron Range has been isotopically dated by the uranium-lead method by Turek et al. (1982, p.1615) at 2749 ± 2 Ma.

COARSE BRECCIA

The best exposure of coarse breccia occurs on the hill northwest of the MacLeod Shaft on the Helen Iron Range and within 100 m of the stratigraphic base of the iron formation (Plate 6). The breccia consists of angular to subangular clasts in a fine-grained tuffaceous matrix. Compositionally, the breccia is oligomictic, however, the texture indicates that it is polymictic. Fragments consist of massive fine-grained, flow laminated and spherulitic varieties of felsic metavolcanic rocks. Clasts up to 1 m in size are present. The unit is unstratified at the base but rapidly becomes finer-grained and is clearly bedded as the base of the iron formation is approached. The upper part of the breccia was likely reworked. Rare tiny shards occur in the matrix of the breccia. The author considers the unit to be a massive breccia flow or phreatic explosion breccia that underwent reworking on its surface. The textural variability favors a phreatic explosion that fragmented and incorporated several flow units displaying different textures. Rare breccia clasts containing internal quartz veining suggests an earlier deposition and veining before incorporation into the present breccia. Coarse breccia also occurs at the ropeway midway in the stratigraphic section on the southern shore of Moran Lake and at the northwestern end of Wawa Lake at the lowest exposed point in the section.

These lower breccias are not as spectacular as the breccias beneath the iron formation and lack great textural variety in the clasts. Most clasts in the lower breccias are fine-grained massive or flow banded aphanitic felsic metavolcanic rocks. Shards were not recognized in the lower breccias.

ASH FLOW BRECCIAS

Throughout the section, units displaying fiamme-like structures are present (Plate 7) which are interpreted to be collapsed pumice. Excellent examples of fiamme occur at the western end of Wawa Lake at the base of the exposed section, on the high hills east of the sinter plant midway in the stratigraphic section and southwest of the MacLeod mine in the upper part of the section. Fiamme, up to and exceeding 10 cm in length, characterized by cusped and pinched ends, are present at the MacLeod Mine. The fiamme occur in a fine-grained tuffaceous matrix or in the tuffaceous matrix of lapilli tuffs and breccia. Well-developed flow banding or bedding may or may not be present. In the outcrops of breccia with fiamme, the clasts are oligomictic and texturally heterogeneous. The clasts are angular to subangular and consist of fine-grained aphanitic and flow banded material. The sharp angular nature of the breccia clasts discounts welding of the ash flow tuffs since the clast morphology lacks evidence of being heated to a sufficiently high temperature to become plasticized and welded together. On the hill east of the sinter plant, fiamme-like features may represent sericite alteration along fractures rather than former pumice.

POLYMICTIC BRECCIAS AND LAPILLI TUFFS

A number of polymictic breccias occur in the stratigraphic section. They consist generally of variably textured felsic clasts with scattered mafic clasts in a chloritic and tuffaceous matrix. These polymictic units are likely representative of debris flows, lahars, or slumps. Reaction rims on some clasts in some units suggest that some were warm to hot at the time of deposition. Phreatic explosion breccias below the iron formation have been coded with polymictic breccias on the map even though their origin is not related to the development of the volcanic stratigraphy but to volcanic fumarolic activity associated with iron formation deposition.

Osterburg (1982, p.20) reported the presence of darker coloured ash and lapilli fragments in amounts approximating 10% in some fragmental units but the author has not observed such high concentrations of darker coloured fragments in the outcrops examined. In thin section, the darker clasts were observed (Osterburg 1982) to be composed of 1) quartz feldspar, opaques and sericite, 2) sericite with minor quartz plus plagioclase and 3) iron stained silicate with minor interstitial quartz plus feldspar plus sericite. Osterburg (1982 p.23) has observed fractures 0.5 to 1.0 mm wide and 2 to 3 cm long filled with sericite, chlorite, stilpnomelone, siderite, hematite, magnetite, pyrite, chloritoid and epidote. He interpreted intergranular clear patches of quartz to represent former amygdules. A large

outcrop of polymictic breccia is exposed in the footwall to the Ruth Iron Range, just east of the south end of Bauldry Lake. The unit cannot be traced laterally. It lies on top of a 33 m thick unit of ferruginous dolomite at the base of cycle one intermediate to felsic metavolcanic rocks. The breccia is matrix-supported, unsorted and contains subangular to angular clasts that exceed 1 m in maximum dimension. Nearly all textural varieties of felsic metavolcanic rocks can be found in the clasts within the outcrop along with large clasts of sulphide and ferruginous dolomite up to 0.66 m in size. The source for the sulphide clasts is unknown but the dolomite clasts are identical to the underlying unit. The breccia unit grades rapidly laterally into bedded fine tuff and lapilli tuff that display grain or clast gradation. This breccia is likely a slump or debris flow that occupies a channel or scour in the volcanic stratigraphy.

Lapilli tuffs are common throughout the section. Most consist of an oligomictic clast population within a fine-grained tuffaceous matrix. Most occurrences are relatively massive and lack bedding or clast grading. The occasional intermediate to mafic clast is present. A distinctive subvariety of this rock type is found in outcrops immediately east of Wawa along Highway 101 in isolated sites in the southwestern part of McMurray Township. At these sites, an oligomictic to polymictic clast population occurs in a matrix of quartz-feldspar crystal tuff.

A thin section of lapilli tuff was prepared from the footwall of the Lucy Iron Range. It consists of 40% carbonate, 10% sericite and 50% fine-grained mosaic of quartz and untwinned plagioclase. The texture is fine-grained, seriate, granoblastic with lobate grain boundaries. The carbonate is anhedral interstitial and stained with iron oxide. The sericite is also interstitial and defines a strong schistosity within the rock.

Osterburg (1982, p.23) interpreted the lapilli tuffs to be distal facies of block and ash flows that originated by sloughing off the sides of growing domes or lava flows. He based his interpretation on the following features:

1. Accessory fragment types are very similar to dome and flow rhyolites
2. Presence of up to 10% juvenile ash and lapilli size fragments
3. Poor sorting of the breccias
4. Proximity to the dome and rhyolites.

While the mechanism proposed by Osterburg (1982) for the lapilli tuffs is plausible, there is no reason to derive all the lapilli tuffs as slough deposits off the flanks of the dome. The lapilli tuffs are typically oligomictic and of a similar texture in contrast to the breccias which are oligomictic but contain a variety of textures. The lapilli tuffs are common in the

stratigraphic section from the Helen to the Josephine-Bartlett Iron Range in Corbiere Township while the coarse breccias are commonly very local in distribution. The author considers the lapilli tuffs to be dominantly pyroclastic flows even though unambiguous criteria supporting this interpretation are lacking.

Osterburg (1982, p.26, 29) reported zones containing spherical structures which be interpreted as crystal-bearing cored accretionary lapilli, armored (rock fragment) accretionary lapilli and clotted accretionary lapilli. The cores of these spherical structures are coarser-grained than the rims.

Bomb-sag features were reported by Osterburg (1982, p.32) in bedded rhyolitic lapilli tuff and interpreted by him to be indicative of subaqueous deposition. The author has observed similar structures on the hill east of the sinter plant of Algoma Ore Properties Ltd. and would not assign either subaerial or subaqueous deposition to them for they likely occur in both environments.

TUFF

Tuff is one of the most common rock types within the intermediate to felsic metavolcanic section. The tuffs range from massive to thinly laminated. The sericite schists mapped throughout the section are in all probability tuffs of one variety or another although primary textural evidence of their origin has destroyed by tectonism. The more spectacular tuffs are the thinly bedded to laminated tuffs. The best exposure of these tuffs is on the prominent ridge of outcrop east of the sinter plant at the MacLeod Mine (Plate 8). Thin tuff beds of one to several centimetres width can be traced across the exposed outcrop. Such regular bed thickness is most consistent with subaqueous deposition beneath storm wave base. These tuffs are dominantly of ash-sized material and would likely be quickly eroded in a subaerial environment. Slightly coarser material, possibly hyalotuff, is locally cross-bedded (Plate 9). Locally, along the contacts of tuff and lapilli tuff or breccia units, sag or drape structures are present (Plate 10). In the section, east of the sinter plant, several thin units up to several centimetres in thickness consist of spherical accretionary lapilli which may reach 4 mm in diameter. Accretionary lapilli are generally rare or not readily recognizable in outcrop. Within some of the thin tuffaceous bands, a weakly developed grain gradation may be present.

A thin section prepared from a fine-grained bedded tuff collected from beneath the Lucy Iron Range, displays a very fine-grained inequigranular-seriate, granoblastic with lobate grain boundary texture. The sample contains an estimated 15% carbonate, 25 to 30% quartz

and possibly untwinned altered plagioclase aggregates and 55 to 60% very fine-grained matrix.

The carbonate is anhedral, interstitial. The quartz plus plagioclase aggregates may be former clasts. The matrix is a very fine-grained mixture of quartz, untwinned plagioclase and sericite.

Goodwin (1962, p.570) reported the presence of banded tuff displaying graded bedding interbedded with coarse breccia, but this was not observed by the author.

CRYSTAL TUFFS

Crystal tuffs are abundant in the footwall felsic metavolcanic rocks. Most are quartz-feldspar crystal tuffs and those interpreted in the field as quartz crystal tuffs almost invariably upon thin section inspection are seen to have a large feldspar component. The crystal tuffs west of the Jubilee-Darwin shear zones often have quartz grains that approach 5 mm in diameter. The quartz grains in these tuffs are commonly larger than those found in similar tuffs north of Wawa Lake. The local presence of lithic fragments of lapilli size in the crystal tuffs west of the Jubilee-Darwin shear zones attests to their pyroclastic origin.

The crystal tuffs north of Wawa contain quartz grains that rarely exceed 2 mm in diameter. The tuffs occur in thick massive units and locally may display weak to faint bedding. Rarely the crystal tuffs north of Wawa Lake contain lithic fragments, generally of lapilli size and felsic in composition. The crystal tuffs south of Wawa lake contain 10 to 15% quartz crystals which may display a very faint bluish opalescence. North of Wawa lake the crystal tuffs contain 5 to 30% quartz but generally average 10 to 15%. The quartz enrichment within the tuffs is on the order of 3 to 5 times the enrichment of the flow rocks and may have resulted from a winnowing process during deposition which removed part of the fine-grained ash component. In a supracrustal sequence south of the map area, Ayres (1983, p.1188) proposed an enrichment factor of 4 when comparing ash flow tuff with a porphyritic rhyolite flow. A similar enrichment ratio appears appropriate for the Wawa crystal tuffs.

The crystal tuffs are a major rock unit within the felsic part of first cycle volcanism and several thin sections were prepared from the crystal tuffs. The tuff is fine- to medium-grained porphyritic-hyaline with granoblastic texture. The quartz grains occur as rounded to subrounded angular to subrounded grains. The grains may be polycrystalline and are often fractured. Some fractures may be rehealed with a very fine-grained mosaic of quartz. Extinction of the quartz grains is wavy and some margins may be cusped implying some resorption in the parent magma. Feldspar occurs as anhedral to subhedral grains that are

commonly fractured and dusted with sericite alteration. The matrix is a fine-grained granoblastic mosaic with up to 10% sericite. Minor carbonate and chlorite are nearly always present and epidote and biotite were noted in several samples. Quartz and plagioclase crystals and crystal fragments occur in quantities generally between 15 and 20% of the rock.

Kidder and McCartney (1946, p.72) interpreted the quartz porphyry and quartz-feldspar porphyries as intrusive rocks rather than tuffs.

Osterburg (1982, p.24) reported the presence of microcline, stilpnomelane, siderite, hematite, pyrite, magnetite, ilmenite and leucoxene in crystal tuffs. Osterburg (1982) reported microcline in quantities up to 10 to 15% which was not observed by the author. Osterburg (1982, p.26) divided the crystal tuffs into quartz-phyric and plagioclase-phyric tuffs and suggested that the feldspar-phyric tuffs decrease upwards stratigraphically in preference to quartz-phyric tuffs. The plagioclase was determined by him to be An₃ to An₇ in composition (Osterburg 1982, p.26).

Nebel (1982, p.30, 44) may have mapped some quartz crystal bearing tuff units as intrusive. The author has not observed a quartz crystal-bearing unit below the Helen Iron Range displaying clear crosscutting relations and considers them all to be crystal tuffs.

MASSIVE FLOWS

Massive intermediate to felsic metavolcanic rocks occur throughout the intermediate to felsic stratigraphy. These units are most abundant on the south side of Wawa Lake as units marginal to and as blocks within the Jubilee Stock. Rocks of this group are massive, lack recognizable primary textures and may represent flows or massive fine-grained tuffs. The massive units marginal to and as blocks within the Jubilee Stock are in all probability hornfelsed massive fine-grained tuff.

A thin section of massive felsic metavolcanic rocks south of Wawa Lake has a fine-grained seriate granoblastic texture. Approximately 90% of the rock is a very fine-grained interlocking mosaic of quartz plus untwinned plagioclase. Minor muscovite, amphibole and biotite is present. The biotite contains tiny inclusions, possibly zircons, with dark radioactive decay halos.

SPHERULITIC FLOWS

Spherulitic flows are common throughout the felsic part of first cycle volcanism. They are not, however, sufficiently distinctive and laterally continuous to serve as marker horizons. Two types of spherulitic units were recognized, those containing solid spherulites and those

containing hollow spherulites. The units with solid spherulites may contain spherulites up to 5 cm in diameter but most commonly they are on the order of 1 cm. The solid spherulites display a distinctive radial structure and are interpreted to represent devitrification of glassy flow rocks. Commonly, units containing solid spherulites display a well-developed flow banding. Spherulites can comprise up to 60% of some spherulitic flows.

One thin section of solid spherulite-bearing rock was prepared. The texture is fine-grained, seriate, granoblastic. The sample contained approximately 30% spherulites as radiating aggregates of plagioclase and quartz. The cores of several spherulites contained a rounded quartz grain possibly a quartz phenocryst in the original melt. The spherulites are set in a matrix consisting of 50% fine-grained granoblastic quartz and untwinned feldspar and 50% fine-grained sericite.

Hollow spherulites up to 3 cm in diameter are present in a number of units but most commonly the hollow spherulites are on the order of 1 cm in diameter (Plate 11). The hollow spherulites are filled with rusty weathering ankerite carbonate enclosed in a prominent rim 1 to 3 mm thick displaying a weak radial structure. The hollow spherulites are interpreted by the author to be amygdules in a glassy flow. Vapour phase recrystallization along the margins of the amygdules formed the radiating rim around the gas cavity. As with flow units with solid spherulites, units containing hollow spherulites also commonly display excellent flow banding.

Flows containing hollow spherulites are commonly highly vesiculated and gas cavities may have originally formed as much as 30 to 40% of the rock. The large size of some of the cavities may indicate low pressure or highly gas charged flows. Lithophysae may be present along bedding planes but metamorphism has largely obliterated or obscured these structures. Nebel (1982, p.20) also suggested that lithophysae are present in some of these units.

Goodwin (1962 p.570) reported spherulites up to 6 inches (15 cm) in diameter but did not specify if they were solid or hollow.

Osterburg (1982, p.16) observed spherulites occurring in concentrations up to 60% of the rock and reported that in thin section they are concentrically zoned. He observed a very fine-grained mosaic of quartz plus plagioclase in the core, followed by a middle zone of fine-grained quartz plus plagioclase with relict outlines of former grains, followed by an outer mosaic without relict outlines of former grains. The spherulites are separated by flow laminae which consist of slightly coarser grained, discontinuous, stringers of quartz plus plagioclase.

Nebel (1982, p.15) reported the solid spherulites have a radiating pattern of quartz plus feldspar with a quartz plus plagioclase mosaic core. Nebel (1982, p.15) attributed the

solid spherulites to devitrification, however, he refers to the hollow spherulites as lithophysae. Nebel (1982, p.20) suggested vapour phase recrystallization formed the hollow spherulites. The author interprets some of the streaky patterns that resemble flow banding as possible collapsed lithophysae.

MISCELLANEOUS PORPHYRITIC FLOWS

Flows of an apparent intermediate composition are present in the intermediate to felsic section of first cycle volcanism. In the area on the western side of Moran Lake and in the area south of the main production shaft of the MacLeod Mine, some relatively massive units exist which appear to be truly intermediate in composition. These rocks are light green in colour and generally very tough or hard to break. They could conceivably be highly altered (silicified) mafic flows which are now interpreted to be dacite in composition. Osterburg (1982) classified the rocks west of Moran Lake as andesite to dacite. He considered them to be massive flows and reported the presence of a pillowed unit which the author could not locate. The author has had no success in tracing these units laterally and considers them to be very minor in distribution and has grouped them with the more typical felsic rocks. Osterburg (1982) places some importance on these intermediate composition units and has based his subdivision of the felsic stratigraphy on their presence. The importance placed on these units by Osterburg (1982) is undoubtedly due to the restricted area examined by him. The author considers them insignificant relative to the genesis of the felsic metavolcanic rocks or in interpreting the volcanic history and stratigraphy of the area.

Osterburg (1982, p.34) reported that the andesitic lava is composed of 20% quartz, 50% plagioclase, 10% chlorite and 10% carbonate. Minor amounts of sericite, stilpnomelane, tourmaline, biotite, siderite, ilmenite, leucoxene and pyrite are present (Osterburg 1982). The reported quartz content would appear to be high for andesite.

INTERPRETATIONS OF THE STRATIGRAPHY OF CYCLE 1 VOLCANISM

The intermediate to felsic metavolcanic rocks have been investigated by several individuals. The first modern investigation was by Goodwin (1962, 1964) who completed an extensive study of these rocks.

INTERPRETATION OF GOODWIN AND SHKLANKA (1967) AND GOODWIN (1962, 1964)

Goodwin and Shklanka (1967) recognized a thickening in the felsic part of cycle one metavolcanic rocks at Wawa. Goodwin (1962, p.561, 568) interpreted the metavolcanic rocks at Wawa to represent an outpouring of intermediate to mafic rocks followed by explosive volcanism of rhyolite-dacite composition which terminated in volcanic-fumarolic activity. Goodwin (1962, p.561) considered all the felsic and mafic volcanic rocks to have a common parent and referred to the thick felsic volcanic section at Wawa as a dome. Goodwin (1962, p.570) proposed that a transitional zone from basalt to rhyolite represented by felsic clasts embedded in a dacite matrix exists at the Wawa centre of volcanism. The proposed transitional zone is 300 to 1000 m thick but this zone was not recognized in regional mapping by the author. The author has observed that the transition between mafic and felsic volcanism is relatively abrupt marked by a mafic breccia unit on the order of 100 m in width in the well-exposed sections on the Lucy, Ruth and Josephine iron ranges. The Wawa dome is estimated by Goodwin (1962) to be 10,000 feet (3333 m) thick tapering to 1500 feet (500 m) at Hawk Junction. The author estimates the felsic section at Wawa to be approximately 2666 m thick and this can be reduced by extracting approximately 500 m of crudely sill-like mafic intrusions. The actual thickness of intermediate to felsic rocks at Wawa is approximately 2000 m. The author estimates 300 m for the thickness of the intermediate to felsic section at Hawk Junction. The intermediate to felsic metavolcanic rocks as described by Goodwin (1962, p.570, 1964, p.687) consist of tuffs composed of rhyolite, dacite and andesite and dikes and sills of quartz porphyry and diorite. He reported that individual units have limited lateral extent and coarse-grained pyroclasts dominate in the west and finer-grained pyroclastic rocks to the east (Goodwin 1962, p.570, 1964, p.689). The coarse pyroclastic rocks south of Boyer Lake, Helen Iron Range are interpreted by Goodwin (1964, p.689) to be of explosive origin representing the destruction of previously deposited volcanic material. This proposal is favored by the author, since the clasts display a variety of textures implying an origin from several different flows. Most clasts are of flow banded rhyolite but he reported the presence of chert and mafic metavolcanic rocks. Chert clasts were not observed by the author and mafic clasts are relatively rare.

Most clasts are considered by Goodwin (1962, p.570, 1964, 689) to be angular to subangular but he reported zones of subrounded clasts which he interpreted as having been abraded by water. The author did not observe zones of rounded to subrounded clasts that could be clearly related to reworking by water. The matrix to the breccia clasts was observed by the author to be of the same composition as the clasts but somewhat darker in colour. Goodwin (1982, p.570) reported the widespread presence of vesicular and

amygdaloidal clasts. While recognized by the author, clasts displaying well preserved gas cavities are not common. Goodwin (1964 p.689) reported that to the east, rhyolite and dacite interfinger and that zones of chlorite-zoisite-carbonate may represent ash interfingered with breccia layers.

Goodwin (1964, p.689) interpreted most of the quartz-feldspar layers to be pyroclastic in origin but classified some as intrusive. The author did not observe clearly identifiable quartz feldspar porphyry intrusive rocks to be present in the Wawa dome as reported by Goodwin (1962, 570) and all quartz feldspar porphyry units were interpreted as pyroclastic in origin. The mafic intrusions cutting the intermediate to felsic metavolcanic rocks are oriented at an oblique angle of 15 to 20° with the stratigraphy. Goodwin (1962, p.572) suggested that this oblique angle is related to the initial slope of the dome, though evidence for such an interpretation is lacking and the intrusions clearly crosscut stratigraphy. Goodwin (1962, p.572) reported an absence of a contact thermal aureole around the mafic intrusions and porphyritic felsic rocks in the Wawa area that have been interpreted by him as intrusive. While such an aureole is not now recognizable for most intrusions, the author is of the opinion that they once existed due to the very fine-grained texture along the margins of some mafic intrusions. These contact aureoles have been largely obliterated by regional metamorphic-metasomatic tectonic events which retrograded the aureoles to regional greenschist facies rank of metamorphism. Some of the small mafic intrusions within the footwall of the Helen Iron Range and margins of some of the larger intrusions consist of nearly 40% rusty brown ankeritic carbonate rhombi and have been so altered as to preclude a reasonable estimation of their original composition. Such pervasive alteration would largely destroy any thermal aureole present.

Goodwin (1962, p.572-573) presented a model of a gas charged volcanic explosion to form the breccias and both upward and distal hybridization to account for present rock compositions. The model is one of progressive destruction and contamination of early formed rhyolite domes and spines by rising effervescing dacite and rhyolitic magmas (Goodwin 1962). The crude fragment alignment and local size gradation may reflect rapid subaqueous deposition (Goodwin 1962, p.573). Goodwin et al. (1985, p.72) recently interpreted the Helen Iron Range and associated volcanic rocks to be deposited in a collapse caldera in response to volcanic fumarolic activity.

INTERPRETATION OF OSTERBURG (1982)

Osterburg (1981, 1982) completed a study of a portion of the Wawa dome defined by Goodwin (1962). Osterburg (1982, p.64) subdivided the volcanic stratigraphy below the west end of the Helen Iron Formation into two cycles.

Cycle one consists of subaqueous bedded deposits produced by subaqueous phreatomagmatic eruptions. The interpreted phreatomagmatic eruption column contained a high percentage of lithic fragments. The pyroclastic flow deposits resulting from these eruptions grade upward into bedded hyalotuffs with accretionary lapilli. Alternatively these bedded pyroclastic flow deposits and hyalotuffs represent a fining upward sequence where the bedded pyroclastic rocks formed by settling of dense fragments and the hyalotuffs represent settling of a fine suspended ash.

Continued volcanism, as the result of a sustained eruption column followed by continuous collapse, formed a thick sequence of non-welded, crystal-and pumice-bearing pyroclastic rocks. Segregation of crystals from pumice, as a result of different setting rates, took place in a subaqueous environment. Volcanism continued as subaqueous phreatomagmatic explosions formed bedded pyroclastic flows and hyalotuffs interbedded with small andesitic lava flows and pillow breccias. The author did not find pillowed units in this stratigraphic sections.

Cycle two volcanism of Osterburg (1982, p.64) is represented by crystal tuff and pumice-bearing tuff emplaced in the manner of a sustained eruption column followed by continuous collapse. This section displays a plagioclase-rich bottom and quartz-rich top that may reflect zonation in the magma chamber. This was followed by intrusive and extrusive domes and related lava flows and block and ash deposits. Dome growth resulted in emplacement of block and ash, lapilli and ash pyroclastic flows, or debris flow deposits.

The second cycle terminated with hot spring fumarolic activity that generated the iron formation.

The author finds little basis for the subdivision proposed by Osterburg (1982). Similar textured, structured and compositional rock types occur throughout the stratigraphic column indicating the influence of similar and repeated volcanic processes throughout the development of the intermediate to felsic part of first cycle volcanism. Osterburg (1982, p.63) cites eight reasons for the section to be subaqueous in deposition, however, most of those reasons are not restricted to subaqueous environments. The author concurs with Osterburg that deposition was likely subaqueous. The author's interpretation is based on the presence of pillowed mafic volcanic rocks above and below the intermediate to felsic metavolcanic rocks and the presence of graded bedding in wacke layers within the iron

formation and within the tuffs below. The presence of thin bedded tuff units that are relatively continuous across exposed outcrops is, in the author's opinion, more consistent with subaqueous deposition than air fall where rapid erosion and scouring would likely destroy such thin bedding.

INTERPRETATION OF NEBEL (1982), MORTON AND NEBEL (1983)

Nebel (1982) examined the area immediately east and adjacent to that of Osterburg over to the Wallbank Lake Fault. Nebel (1982, p.24) divided the stratigraphy into an upper and lower pyroclastic series separated by the tuff breccia reported by Osterburg (1982). He did not encounter the andesite and pillow breccia reported by Osterburg (1982, p.3435).

Nebel considered the central part of this area as proximal and the flanks distal to a metavolcanic source since the pumice content of the fragmental rocks appeared to him to increase both east and west of the central area. Bedded tuffs below the iron formation were mapped as metasedimentary rocks by Nebel (1982, p.46). The author included them with the felsic metavolcanic rocks since appear to have experienced only limited transport and reworking, although they do display excellent clast gradation. These tuffs are dark brown in colour due to weathering of sideritic carbonate cement. Nebel (1982, p.47) reported the matrix of the tuffs below the iron formation to consist of fine-grained quartz, carbonate, chlorite, sericite, opaques and stilpnomelane.

In addition to graded bedding, cross-bedding and scour structures are present. On the basis of these structures the current direction for detritus transport was from west to east (Nebel 1982, p.48). The author has confirmed Nebel's (1982) observations. The angular nature of the clasts indicates little reworking and Nebel (1982, p.55) considers cross-bedding and scour features to indicate a shallow water environment. In the author's opinion, water depth would have to be at least greater than storm wave base or such well preserved structures would have been destroyed. The water depth was likely relatively shallow but the precise depth cannot be estimated.

The pyroclastic breccia of the lower pyroclastic series was interpreted to have formed as a result of an explosive eruption which was terminated by growth of a lava dome to the east (Nebel 1982, p.65). This was followed by an additional explosive eruption which on the basis of lateral facies changes (clast size) had a vent towards the west. This second cycle of volcanism was followed by a third cycle that deposited a series of pyroclastic rocks similar to these formed in the first explosive event (Nebel 1982, p.66). The last period of explosive volcanism was followed by hot spring and fumarolic activity. Local hydro-explosion breccias due to boiling occurred directly beneath the iron formation (Nebel 1982, p.67). The author

has observed that hydro-explosion breccias are common features below the Michipicoten-type iron ranges.

Morton and Nebel (1983, p.39) have reinterpreted the stratigraphy and concluded that the upper part or the third period of explosive volcanism is subaerial due to the presence of abundant pumice which they considered analogous to recent ash flows. If the volume of pumice is truly indicative of subaerial eruption, the entire stratigraphic section would have to be considered as potentially subaerial since pumice is locally abundant in the lower part of the section as fiamme.

The volcanic environment was interpreted by Morton and Nebel (1983, p.40) to be one of caldera formation and late stage dome extrusion. As discussed in the structural section of this report, the author finds no preserved structural evidence for caldera-like structures in the footwall rocks of the Helen Iron Range. The laterally extensive alteration implies laterally continuous aquifers which could not exist if faulting and collapse associated with caldera development took place. The defining of a caldera structure will involve the investigation of a much larger area than the one examined by Morton and Nebel (1983).

The history of development from the stratigraphic bottom to stratigraphic top as given by Morton and Nebel (1983, p.60) is:

1. Approximately 266 m of bedded pyroclastic rocks, flow deposits, hyalotuffs and lava flows representing hyaloclastic eruptions to sustained eruption columns were deposited. Eruption column collapse and periodic felsic lava extrusion are represented by the section. This took place under subaerial to subaqueous conditions.
2. Approximately 1000 m of pyroclastic flows that are non-graded, lack associated thin bedded units, contain abundant pumice and contain 10 to 15% lithic clasts were deposited. They are interpreted to represent non-welded, partly fluidized subaerial pyroclastic flows. This may be a period of caldera collapse.
3. Dome formation followed by collapse of the domes to form block and ash flows. Submergence and hydrothermal activity occurred to form the Helen Iron Formation.

For reasons previously cited, the author believes deposition was entirely subaqueous, but shallow, and that there is no preserved evidence of a caldera-like structure in the area of the Helen Iron Range.

Figures 27 and 28 are respectively AFM and cation plots of intermediate to felsic metavolcanic rocks north of Wawa. The chemical data indicate a good calc-alkalic suite of rhyolite to dacite composition. The data for the felsic part of first cycle volcanism display somewhat more scatter than data for subcycle one or cycle two metavolcanic rocks. The samples are dominantly of crystal tuffs and from the centres of clasts from coarse breccia

units. Sampling was completed for the purpose of establishing possible melt trends and not for the purpose of establishing bulk rock chemistry and the application of rock names. Polymictic breccias, tuffs and units of more problematical origin were not sampled for chemistry. Clasts of quartz porphyry flows are not as common in this cycle of volcanism as they are in the second cycle. Aphanitic massive and flow-banded clasts are more common.

This first cycle of volcanism displays more pervasive carbonatization than second cycle volcanism and the first cycle contains extensive zones of chloritoid development. The cycle is much more altered and metasomatized than subcycle one and cycle two felsic metavolcanic rocks. The data scatter is likely in part due to this greater degree of alteration.

South of Wawa Lake and well exposed along Highway 101, are intermediate to felsic metavolcanic rocks that consist of massive, spherulitic, tuffaceous, breccia and quartz-feldspar crystal tuff units. The rocks south of Wawa Lake are different from the rocks north of Wawa Lake in that the secondary internal structures; i.e. schistosity, are at a considerably different attitude than those north of the lake, they are much less carbonated and much harder and less fissile. A select group of massive units, crystal tuffs and one spherulitic flow was sampled for chemical analysis. The samples were selected in hopes they closely approximate melt compositions. The units sampled are located in the thermal aureole of the Jubilee Stock and undoubtedly hornfelsed. Some of the massive units of intermediate to felsic metavolcanic rocks may be tuffs in which the clastic texture is no longer visible. The author did not sample most tuff units north of the lake since such rocks were likely originally porous and likely more susceptible to alteration. In spite of sampling problems, the chemistry of the intermediate to felsic rocks south of the lake is essentially identical to those north of the lake (Figures 29 and 30). The author considers them part of first cycle volcanism but faulting and possible folding across Wawa Lake have made correlation of rock units across the lake impossible. Turek et al. (1982, p.1615) have obtained a U-Pb age of 2744 ± 10 Ma. on crystal tuffs south of Wawa Lake which is in close agreement with the U-Pb age of 2749 ± 2 Ma. on felsic rocks below the Helen Iron Range north of Wawa Lake. The intermediate to felsic metavolcanic rocks north and south of Wawa Lake are thus part of the same cycle of volcanism but likely laterally displayed from their original stratigraphic position across the Wawa Lake Fault.

CYCLE 2 INTERMEDIATE TO FELSIC METAVOLCANIC ROCKS

- On the east flank of the Jubilee Stock, south of Stanley Lake, a large area underlain by flow-banded quartz porphyry flows is present. These flows may or may not be part of cycle one volcanism. The convoluted flow banding is well-developed and quartz phenocrysts

up to 1 mm in diameter may form 5% of the rock. The unit has a general east-west elongation but the flow banding strikes crudely north to northeast and dips at low angles to the east. These quartz porphyry flows are interpreted by the author to represent a filling of a depression on the flanks of the structurally high-level Jubilee Stock. The flows may represent cycle one intermediate to felsic volcanism since the stock has been dated by U-Pb techniques as 2745 ± 3 Ma. (Sullivan 1985) and is approximately equivalent in age to the upper part of felsic volcanism of cycle one (Turek et al 1982, p.1615). Isotopic age dating would be required to establish to which cycle these flows belong. Figures 19 and 20 are respectively AFM and cation plots for the Stanley Lake porphyry flows. Eight samples from Stanley Lake all plot in the rhyolite field on a cation plot.

Volcanic rocks of cycle two are centered north of the Magpie River in the west central part of Chabanel Township. This volcanic centre has been dated by Turek et al. (1982, p.1615, 1984, p.460) using U-Pb isotopic techniques as being 2696 ± 2 Ma. and 2698 ± 11 Ma. The rock types observed are identical to those found in cycle one felsic rocks with the possible exception of the absence of spherulitic flows and fiamme-bearing fragmental rocks. Massive units of felsic to intermediate composition and some rare units found in cycle one, such as accretionary lapilli tuff, were also not found.

Cycle two felsic metavolcanic rocks consist of tuff, laminated tuff crystal tuff, lapilli tuff and breccia.

TUFF, LAMINATED TUFF

Tuff units without quartz or feldspar crystals are present but rare. They are identical in appearance to those found in cycle one.

QUARTZ-FELDSPAR CRYSTAL TUFF

Crystal tuff in one form or another is the dominant rock unit in cycle two volcanic rocks. Not only is it a major unit, but also it composes the dominant matrix to the lapilli tuffs and breccias. The quartz crystals are 1 to 2 mm in diameter, rarely have a faint bluish opalescence and occur in concentrations of 5 to 20% when serving as matrix to lapilli tuffs and breccias. The quartz content within crystal tuff units maybe somewhat higher than the quartz content found in the crystal tuff serving as matrix to the lapilli tuffs and breccias. The matrix of the crystal tuff is fine-grained, rich in sericite and contains traces of chlorite. The unit may be faintly bedded and in places grades laterally and vertically into metasedimentary rocks. Thin siltstone layers may occur in the crystal tuffs in proximity to

the metasedimentary rocks. Crystal tuffs of cycle two volcanism appear identical to crystal tuffs of cycle one.

Crystal tuffs contain 15 to 20% quartz which represents an approximate 4 fold increase over that present in the quartz porphyry clasts of the breccia. Quartz in the wacke to subarkose layers is estimated at 30 to 40% or at least double that found in the crystal tuffs. In the author's opinion, the metasedimentary rocks on the long linear lake north of the Magpie River, in western Chabanel Township, as well as the clastic metasedimentary rocks throughout other parts of the Wawa supracrustal sequence, are derived dominantly by reworking of crystal tuff deposits. Considering the estimated quantity of quartz found in the wackes over that found in quartz porphyry fragments, one reaches the conclusion that the quartz in the wackes represents at least an 8-fold increase over the clasts in the breccia.

LAPILLI TUFFS

Lapilli tuffs are common in second cycle felsic metavolcanic rocks due west of the long linear lake north of the Magpie River. The fragments are commonly fine-grained, aphanitic felsic metavolcanic rocks but some clasts are quartz porphyry containing several percent quartz as tiny 1 mm phenocrysts. The matrix is commonly quartz-feldspar crystal tuff. Bedding is uncommon and clast size gradation was not observed. Thin siltstone and wacke bands are commonly present in both the eastern and western parts of the second cycle metavolcanic rocks where they interfinger with metasedimentary rocks. Narrow units, generally less than 1 m in width containing clast-supported, angular, felsic fragments of lapilli size are common in cycle two felsic metavolcanic rocks. The author interprets these units to be reworked, with the crystal tuff matrix being winnowed away. These units were coded with the metavolcanic rocks on the map.

BRECCIA

Breccia was observed west of the long linear lake north of the Magpie River but the most spectacular breccia exposure is located due south of the long linear lake (Plate 12). Fragments in this breccia exceed 4 m in maximum dimension and most are fine-grained aphanitic and contain 1 to 5%, 1 mm quartz phenocrysts. These fragments likely represent samples of the parent magma that gave rise to the crystal tuffs. A stratigraphic section near the long linear lake north of the Magpie River is particularly informative. At this lake, the rocks are metasedimentary rocks. They consist of thin bedded wackes, siltstones and rare conglomerates displaying grain gradation and flame structures. Moving south from the lake,

sedimentary structures and bedding features rapidly disappear. At the hill south of the lake, the rocks are well-exposed, massive, unsorted, coarse volcanic breccia. One can in proximity of this long linear lake move either laterally (east-west) or in a north-south direction from sedimentary rock to volcanic rock.

An interesting feature observed in several breccias is that quartz veins cut the clasts but not the matrix. This suggests that some of the clasts represent disrupted pre-existing volcanic rocks and are not directly related genetically to either the volcanic event forming the lithologic unit or the matrix enclosing the clasts.

Thin sections were prepared from a number of quartz porphyry clasts collected from the coarse breccia units. The texture is fine- to medium-grained porphyritic-seriate. The matrix is fine-grained granoblastic. The mode is estimated as 5 to 8% quartz phenocrysts, 30 to 45% plagioclase feldspar phenocrysts (An₃₅) and 50 to 65% matrix. Trace to minor amounts of chlorite, carbonate, sericite and biotite are present.

The matrix is an anhedral mosaic of quartz plus untwinned plagioclase. Sericite is abundant and may compose in excess of 10% of the rock.

Quartz occurs as rounded to subrounded phenocrysts. These phenocrysts may be polycrystalline and display a weak wavy extinction. Locally cusped to embayed margins suggest some resorption of the quartz.

The plagioclase feldspar phenocrysts occur as anhedral to euhedral angular to subangular grains. The plagioclase displays good albite twinning and is present as single grains and clusters of grains. The crystals are often turbid due to alteration and some crystals are clearly fractured.

Goodwin (1962, p.570) referred to the felsic metavolcanic rocks of cycle two as the Catfish Lake Dome and interpreted them to be a folded extension of the Wawa volcanic centre. Lead-uranium dating previously cited indicates that the Wawa and Catfish Lakes felsic piles are at least 50 million years apart in age and therefore are not correlative. Goodwin (1962, p.570) interpreted the sequence to be underlain by rhyodacite to andesite tuff flows to the west and overlain by andesite flows to the east. On the basis of facing directions observed by the author, the intermediate to felsic metavolcanic rocks are underlain and interfinger with clastic metasedimentary rocks to the east which overlie intermediate to mafic metavolcanic rocks of cycle two. The Catfish Lake Dome is in turn overlain to the west by a mixture of intermediate to mafic flows and Dore-type metasedimentary rocks.

The Catfish Lake Dome is estimated by Goodwin (1962, p.571) to be 2000 feet thick and 4 miles long. Folding of the stratigraphic section makes original thickness estimates open to debate and the section may be either thinner or thicker.

Goodwin (1982, p.571) reported the presence of quartz porphyry sills and dikes, however, the author observed only one quartz porphyry intrusion. This unit displayed crosscutting contacts and quartz grains 1 to 2 mm larger than the quartz-feldspar crystal tuffs. This intrusive rock may have been a feeder for overlying crystal tuff units not now exposed or which have been removed by erosion. Goodwin (1982, p.572) reported a quartz feldspar porphyry intrusion 500 by 3000 feet in the Catfish Lake Dome. However, no intrusion of this size was encountered in the present mapping. Goodwin (1962, p.571) proposed that the coarse and angular nature of the breccias present in the Catfish Lake Dome indicate a proximal volcanic environment. Both the author and Goodwin (1962, p.572) recognized an interfingering relationship between these metavolcanic rocks and Dore-type metasedimentary rocks.

At Steep Hill Falls, on the Magpie River, a spectacular breccia of intermediate composition is present (Plate 13). The unit is well exposed north of the dam-site and is likely tectonically thickened, being compressed by folding between metasedimentary rocks to the south and mafic metavolcanic rocks to the east. The unit appears to be local in nature. Goodwin (1962, p.571) described the unit as 1000 feet thick and 2 miles long. The length could not be confirmed and the great thickness is likely due to fold repetition of the unit.

The breccia is oligomictic with two clast types. One clast type contains from several percent to 20% of 1 to 4 mm feldspar phenocrysts while the other clast type is identical except for the lack of phenocrysts. Amygdules may compose up to 20% of the fragments. Deformation has elongated the clasts and their long axes plunge shallowly to the east. The unit lacks good bedding or sorting but faint bedding maybe locally present. Amygdules up to 8 mm in long dimension are present and some are quartz-filled. The clasts are subrounded, subangular, to angular and both matrix-and clast-supported outcrops were observed. Clasts compose more than 50% of the rock and have dimensions up to 25 by 15 cm. The author observed that the matrix is chlorite-rich and weathers low with respect to the clasts. Several clasts of possible fine-grained mafic tuff were observed in the matrix. Bleached reaction rims up to several millimetres in width were noted on a number of clasts. This unusual unit is interpreted by the author as probably a debris flow or lahar. Goodwin (1962, p.571) reported welding in the unit and interpreted it to represent a glowing avalanche deposit. The author did not observe evidence for welding.

A collection of clasts was made from the coarse breccias of cycle two intermediate to felsic metavolcanic rocks south of the long linear lake north of the Magpie River. Nearly all, if not all of these clasts, have phenocrystic quartz in quantities up to 2 to 4% in a aphanitic groundmass. The chemical data for these samples plotted on AFM and cation plots indicate they are calc-alkalic rhyolites (Figures 31 and 32). The breccias have a

rhyolitic parent and the derived metasedimentary rocks therefore have their roots in rhyolitic calc-alkalic volcanism. Rocks which could be interpreted as most closely approximating felsic melt compositions of subcycle one, cycle one and cycle two, all plot in the rhyolitic field of calc-alkalic volcanism in a reasonably tight cluster. It appears that regardless of the position or age of intermediate to felsic volcanism in the map area, major element chemistry does not show significant differences.

METASEDIMENTARY ROCKS (MAP UNIT 4)

The metasedimentary rocks of the Wawa greenstone belt are extensively developed. Conglomeratic facies metasedimentary rocks exposed along the shore of Lake Superior were the first rocks described in the area by Logan (1847).

Early workers considered the conglomerates to be of Huronian age and the relationship of the conglomerates to the older metavolcanic rocks was debated for a considerable period of time (Logan 1847, 1863; Coleman 1899, 1900; Coleman and Willmott 1902; Bell 1905; Parsons 1915; Collins and Quirke 1926; Burwash 1935a, 1935b; Cooke 1937; and Bruce 1940). The conglomerates were referred to as the Dore conglomerates by Coleman and Willmott (1902). Both the conglomerates and associated metasedimentary rocks are presently referred to as Dore metasedimentary rocks.

Modern interpretation of these metasedimentary rocks began with Goodwin (1962) and Goodwin and Shklanka (1967). Detailed studies and interpretation have only recently begun and are represented by the works of Foster (1981), Neale (1981) Thomas (1984) and Ayres (1983). The work of Ayres (1983) is within the Gamitagama Lake greenstone belt to the south of Wawa, however, a number of interpretations applied to this belt by Ayres (1983) are in the author's opinion applicable to the Wawa supracrustal rocks.

The Dore megaconglomerate and associated metasedimentary rocks on Lake Superior can be traced eastward across Highway 17 along and south of the Magpie River to Lena Lake. Numerous left-lateral offsets occur along the strike of this unit. The size and volume of conglomerate clasts decrease rapidly eastward while the volume of wacke, siltstone and argillite increases. The upper part of the section underwent northeast-striking strike-slip or thrust faulting along the Magpie River. This strike-slip or thrust faulting changes to transverse faulting east of the Magpie River where it separates the northeast striking Dore metasedimentary rocks to the south from northwest-striking intermediate to mafic metavolcanic rocks to the north. The transverse fault lies parallel to the trend of the metasedimentary rocks but almost at right angles to the intermediate to mafic metavolcanic rocks to the north. The Dore metasedimentary rocks at Mildred Lake have been referred to

as the Eleanor Slates (Coleman and Willmott 1902, p.155) and they have been faulted north to Mildred Lake, along the left-lateral transverse Mildred Lake Fault, where they lie conformably above the intermediate to mafic metavolcanic rocks of cycle two volcanism. The clastic metasedimentary rocks north, south and east of Mildred Lake are dominantly wackes, siltstones and argillite. The north facing stratigraphic section above the Lucy Iron Range has likely been repeated by strike-slip or thrust faulting since it is nearly twice as thick as its offset western extension west of Lena Lake. The metasedimentary rocks above the Lucy Iron Range are offset by the left-lateral transverse Bauldry Lake Fault and have been subjected to low angle oblique faulting which has cut out the intermediate to mafic metavolcanic rocks of cycle two. This faulting places the metasedimentary rocks directly on top of the iron formation of the Ruth Iron Range. Continuing east along the Ruth Iron Range the metasedimentary rocks are again faulted northward by the left-lateral transverse Goetz Lake Fault and form part of the hanging-wall stratigraphy above the Josephine Iron Range in Corbiere Township (outside the map area). Conglomerate is largely absent or uncommon within the metasedimentary rocks in this area and the metasedimentary rocks are composed dominantly of wacke, siltstone and argillite. Plutonic clasts of trondhjemite composition decrease in size and number and disappear as one moves eastward from Lake Superior to the Josephine Iron Range.

North of the Magpie River in west central Chabanel Township and along the Magpie River to Steep Hill Falls lies a metasedimentary succession whose relationship to the Dore metasedimentary rocks is not yet precisely known due to intervening faulting and folding. These metasedimentary rocks consist of wacke, conglomerate, argillite and siltstone and intimately interfinger with fine to coarse breccias of cycle two intermediate to felsic metavolcanic rocks.

At the Lucy Iron Range, 1000 m of massive to pillowed intermediate to mafic metavolcanic rocks lie above the Michipicoten-type iron formation of the Lucy Iron Range and laminated chert pebble conglomerates that are derived from the iron-formation occur near the base of the overlying metasedimentary section. The metasedimentary rocks are much younger than the Michipicoten Iron Formation and occur well into second cycle volcanism. In the area north of the Magpie River, the metasedimentary rocks intimately interfinger with the felsic part of second cycle volcanism.

In Lendrum Township, west of Chabanel Township, Massey (1985, p.24) reported an intimate interfingering of Dore metasedimentary rocks and intermediate to felsic metavolcanic rocks. This relationship is the same as seen by the author and suggests volcanism with concomitant erosion, transportation and deposition of a subaqueous fan on the flanks of an active volcano. Sediment transport directions based on asymmetric ripples and cross-bed

truncations are consistent indicating a west to east paleoslope. The preserved felsic metavolcanic rocks of cycle two are relatively extensive, certainly in much greater quantity than that described by Ayres (1983, p.1168) for the Gamitagama Lake greenstone belt. However, similar to the relationship described by Ayres (1983, p.1168) the volume of preserved metasedimentary rocks combined with a quartz enrichment of approximately 8 times that found in volcanic clasts interpreted as representative of the primary felsic magma indicates that the volume of second cycle volcanism was many times that presently preserved. The anticipated volume of felsic volcanism could equal or exceed the volume of second cycle intermediate to mafic volcanism.

Sedimentation within the Wawa supracrustal sequence is almost exclusively restricted to second cycle volcanism. Wacke and graphite-argillite sedimentation occurs with and is intimately related to the origin of the iron formation but volumetrically is only a very minor clastic metasedimentary unit. Minor interflow argillite, siltstone and rare wacke are present in both first and second cycle volcanism, however, these interflow metasedimentary rocks are insignificant in abundance relative to those associated with second cycle felsic volcanism.

In the Gros Gap area west of the map area, Collins and Quirke (1926, p.14, 16) reported that Dore conglomerate consists of volcanic detritus and granite that vary rapidly in composition. The Dore conglomerate is reported to be cut by granite on islands in Lake Superior (Collins and Quirke 1926, p.16). They reported that the conglomerate in the Gros Gap area is approximately ten times the volume of wacke, which contrasts strongly with the very small quantities of conglomerate found associated with the wackes in the present map area which lies 8 to 9 km to the east of Gros Gap.

Collins and Quirke (1926, p.18, 19) interpreted the conglomerates to be talus or scree, recognized the intimate relationship between felsic metavolcanic rocks and metasedimentary rocks in the Magpie River area and recognized that it was often difficult to separate metasedimentary rocks from the felsic metavolcanic rocks. The Dore metasedimentary rocks were interpreted by Collins and Quirke (1926, p.22), in the area of Gros Gap, to be subaerial. Collins and Quirke (1926, p.21) reported that the transition from metavolcanic rocks to metasedimentary rocks may take place over distances of 50 feet. Erosion was interpreted to be rapid in areas of rugged relief and waning volcanism and that subaerial erosion was interpreted to be followed by reworking by water, possibly streams (Collins and Quirke 1926, p.22, 23). The conglomerate is poorly sorted and has a matrix of wacke composed of quartz, plagioclase and chlorite that has been affected by dynamic metamorphism (Collins and Quirke 1926, p.22; Bell 1905, p.340). The granitic boulders were interpreted by Collins and Quirke (1926, p.25) to be derived from the granitic terrain north of the belt but the author has not observed similar granitic rocks in the close-by Molybdenite

Lake Area (Mandziuk 1981) immediately north of the metasedimentary rocks. All other reported metavolcanic and iron formation units can be found in the stratigraphic section below or lateral to the Dore conglomerates. Collins and Quirke (1926, p.24) reported that metasedimentary rocks in contact with granitic rocks near Gros Gap lack evidence for contact metamorphism.

Working in the same area as Collins and Quirke (1926), Massey (1985, p.22) described the Dore conglomerate in Lendrum Township as containing thin wacke interlayers. These interlayers were classified by him as lithic wacke to subarkose and contain biotite, chlorite, sericite, epidote, quartz and feldspar. The wacke interbeds were reported to be up to 60 to 70 cm thick and the volume of lithic wacke with respect to subarkose increases to the east where the metasedimentary rocks interfinger with intermediate to felsic metavolcanic rocks (Massey 1985, p.21, 24).

Siltstone-argillite beds within the Dore metasedimentary rocks are composed of chlorite, quartz, opaques and variably developed biotite porphyroblasts (Massey 1985, p.23). These fine-grained metasedimentary rocks are finely laminated and occasionally display graded bedding (Massey 1985 p.23).

Massey (1985, p.22) found gabbro-diorite clasts without granite clasts in a phase of the Dore conglomerate that interfingers with the typical Dore conglomerate that bears granite clasts.

Massey (1985, p.24) considered that sedimentation and intermediate to felsic volcanism took place simultaneously. The author concurs with this interpretation. Massey (1985 personal communication) interpreted the thick sequence of polymictic conglomerates with interbedded wackes to represent subaerial proximal braided stream deposits. The polymictic conglomerates pass upward into a sequence of interbedded wacke-siltstones and laminated siltstone-sandstones that are partially turbiditic (Massey 1985, p.26). Massey (1985, p.25, 26) did not find paleocurrent indicators. Massey (1985) interpreted the granitic clasts to be from an external batholithic source rather than from small subvolcanic stocks and apophyses. The rapidly increasing size and relative volume of the granitic clasts suggests a westerly source that may now exist beneath Lake Superior, beneath the Proterozoic rocks.

Goodwin (1962, p.561) recognized that the metasedimentary rocks were deposited subaqueously, however, he proposed that originally the associated metavolcanic rocks were originally subaerial. He proposed that the granite detritus was from an exposed granitic terrain, presumably external to the belt, but he did not speculate as to the location of this granitic area. The coarse conglomerate which displays poor sorting and local clast or grain gradation in the west was interpreted by Goodwin and Shklanka (1967, p.790) to have been subaerially eroded. This interpretation is in agreement with Collins and Quirke (1926).

Individual conglomerate lenses up to 4000 feet and 10 miles long are reported by Goodwin and Shklanka (1967, p.790) but were not observed by the author in the map area. They interpreted the Dore metasedimentary rocks to be an intraformational clastic zone that fines from west to east within a volcanic assemblage. The poor sorting, crude stratification, subrounding of clasts and great variation in thickness, indicate rapid erosion and deposition in a hilly volcanic terrain of substantial relief (Goodwin 1962, p.581, Goodwin and Shklanka 1967, p.740; Froberg 1935, p.48).

Goodwin (1962, p.582) suggested that the granitic detritus could be from near surface intrusive equivalents of the extrusive rocks. The author concurs with this interpretation. Goodwin (1962, p.582) suggests that the conglomerates were deposited in alluvial fans and lenses near their source. The conglomerates consist of well rounded to highly stretched clasts with interbeds of wacke up to 12 inches that are commonly graded (Goodwin 1962, p.581). He observed that the conglomerates display poor bedding, poor sorting, discontinuous bedding and that contrasting clast compositions indicate multiple source areas (Goodwin 1962, p.581). The presence of graded bedded units was interpreted by him to indicate deep water deposition which contrasts with the proposed alluvial fan environment proposed for the associated conglomerates.

The model of Goodwin and Shklanka (1967) is in relative close agreement with the ideas of Collins and Quirke (1926). Observing the lithologic distribution Goodwin and Shklanka (1967) proposed that the basin of deposition increased in depth towards the east. They related oxide facies iron formation in the west and sulphide facies iron formation in the east to physical and chemical conditions resulting from this increasing water depth. Paleocurrent directions indicate west to east sediment transport. However, the presence of phreatic explosion breccias below the iron formation and of relatively large and abundant amygdulites in the associated metavolcanic rocks suggest relatively shallow water conditions throughout the mapped strike length of the iron formation.

The Dore metasedimentary rocks are concomitant with second cycle intermediate to felsic volcanism. Observations by Neale (1981) and Thomas (1984) in the upper portion of the Dore stratigraphy are more consistent with an alluvial fan-fluvial environment than a deep basin. As with the iron formation, the preservation of the delicate sedimentary structures found in the metasedimentary rocks would indicate deposition below storm wave base.

Goodwin (1962, p.581) described the finer-grained clastic metasedimentary rocks as thinly laminated argillite units that locally display scour and slump structures. Thin zones of carbonaceous shale with pyrite are present. The argillite units are present in widths up to several hundred feet thick (Goodwin 1962 p.581) and is intercalated with wacke. Within the

project area, units of argillite approaching the thickness reported by Goodwin (1962) have not been found. The argillite and wacke occur together as thin bedded units, rarely do individual beds exceed 1 foot in thickness.

North of the Magpie River in west-central Chabanel Township, the intimate relationship between sedimentation and second cycle felsic volcanism was studied by Foster (1981), who examined a 350 m section at the eastern end of a long linear lake. Figure 33 is a composite diagram of the section as interpreted by Foster (1981). Moving up the stratigraphy south from the lake towards the Magpie River, the first 60 m consists of thin bedded turbidites of wacke composition and volcanic ash. The wacke layers are from 3 mm to 25 cm thick, have an average grain size of 0.15 mm, are normally graded and may contain up to 40% angular lithic clasts (Foster 1981, p.17). Argillite beds are from 1 mm to 2.5 cm thick and display primary scours, flame structures, dewatering features, graded bedding and ripple marks (Foster 1981, p.17). In examining this same general area, the author was unable to locate ripple marks but the other features are common (Plate 14).

The associated pyroclastic beds vary from 2.5 to 40 cm thick, are massive, commonly both normally and reversely graded and composed of angular quartz, feldspar and lithic fragments up to 0.7 mm (Foster 1981, p.18). The interpretation that these units are pyroclastic ash-flow sheets is based on the lack of channeling and dewatering structures (Foster 1981, p.19). On the basis of the thin bedded nature of the units and close association with undoubted metasedimentary rocks, the author interprets these units as metasedimentary rocks.

The overlying conglomerate is 10 m thick, proximal to a coarse breccia to the east and displays a sharp lower contact. It consists of 1.5 m of sandy conglomerate, 1.0 m pebbly sandstone and 6.0 m of thin bedded to laminated turbidites (Foster 1981, p.23, 26). The argillite content increases upward and scours, rip-up clasts, load casts, flame structures and soft sediment slumps are present (Foster 1981). At the top, some argillite beds are disrupted and destroyed (Foster 1981, p.26).

The first pyroclastic rock unit which lies above the conglomerate is 30 to 40 m thick, contains planar and low angle cross laminations and is composed of more than 40% quartz, feldspar and lithic fragments (Foster 1981, p.28). The clasts are lapilli-sized felsic volcanic rocks and may be concentrated into pockets and layers. (Foster 1981, p.28).

Overlying in sharp contact with the above pyroclastic unit is a second pyroclastic unit approximately 50 m thick of coarse volcanic breccia that is normally graded to lapilli tuff at the top (Foster 1981, p.32, 35). The breccia consists of massive and porphyritic clasts some of which are flow banded. The clasts are angular to subrounded in shape and set in a quartz-

feldspar crystal tuff matrix. From bottom to top, Foster (1981, p.35) described the unit as tuff breccia, lapilli tuff and then crystal or ash tuff.

Above the second pyroclastic unit, 50 to 70 m of thin bedded to laminated siltstone-argillites are present but were not described in detail by Foster (1981, p.10).

Foster (1981, p.41, 45) found that pumice is rare in the deposits and that the ash is efficiently sorted from the lapilli and blocks. Foster (1981, p.45) interpreted the metavolcanic rocks to display characteristics of both subaerial and subaqueous deposition. Redeposition of the volcanic material was by submarine flows on the flanks of an active volcano (Foster 1981, p.46, 47). Both volcanism and sedimentation were repetitive (Foster 1981). The author concurs with the general ideas of Foster (1981), however, some of the units interpreted by him as pyroclastic may be relatively massive sedimentary units formed by debris flows off the flanks of the volcano. The variation in clast types and close association with metasedimentary rocks favours a sedimentary origin. Scattered outcrops proximal to second cycle felsic metavolcanic rocks, particularly in the area north of the Magpie River, consist dominantly or exclusively of lapilli size felsic volcanic clasts. They are interpreted by the author to have resulted from winnowing of the crystal tuff matrix during reworking. These units are commonly less than 1 m thick, lenticular in cross section, occur in proximity to the metasedimentary rocks-metavolcanic interface and are interpreted by the author to be epiclastic in nature. The author has classified some of them as metasedimentary rocks, consistent with the associated rock types, while Foster (1981, p.28) places similar units with pyroclastic rocks.

A number of thin sections were prepared from the coarser wacke beds. These beds are generally one to 5 cm thick but may be 15 cm or more thick.

The rocks are fine- to medium-grained, seriate and granoblastic with lobate grain boundaries. Quartz varies from 10 to 65%, plagioclase from 20 to 50%, carbonate trace to 30%, sericite 10 to 20% and rock fragments 0 to 10%. Trace to minor amounts of opaques, chlorite and epidote were observed.

The quartz occurs as angular grains, some of which are polycrystalline, in a matrix of finer-grained quartz. Wavy extinction may or may not be present.

Plagioclase is present as angular fractured grains that are pervasively saussuritized. The carbonate is present as anhedral interstitial grains. The sericite occurs as very fine grains, crudely tabular in outline. Their preferred orientation defines a schistosity.

The lithic fragments are angular, recrystallized, fine-grained and consist of felsic volcanic rocks.

The metasedimentary rocks are petrographically immature.

Metasedimentary rocks are well exposed in the area north of the long linear lake north of the Magpie River towards Steep Hill Falls and along the east and west sides of the Magpie River south of Steep Hill Falls. The metasedimentary rocks consist of argillite, siltstone and wacke with very rare conglomerate. Graded bedding, flame structures, rip ups, soft sediment slumps and dewatering features are well preserved (Plates 14, 15, 16, 17). Cross-bedding is uncommon to rare and poorly-developed, graded bedding and flame structures typify the section. The section on the east side of the Magpie River is recumbent and displays a well developed cleavage. Slight movement along the cleavage plane has produced pseudo flame structures in several outcrops.

Thin bedded wacke is exposed south of the Magpie River east of the west boundary of Chabanel Township. These metasedimentary rocks lie on the north flank of the Legarde Lake Anticline. South of the river graded bedding indicates a south-facing sequence though numerous opposing facing directions occur. Near the intermediate to mafic metavolcanic rocks a pebble conglomerate with wacke layers is isoclinally folded and opposing facing directions on grain gradation are ubiquitous. The stratigraphic section moving south from the metasedimentary rocks is intermediate to mafic metavolcanic rocks (cycle two), iron formation lenses (attenuated portions of the Mildred Iron Range) and intermediate to felsic metavolcanic rocks (cycle one). On the basis of comparison with other areas within the Wawa supracrustal rocks that are much less severely deformed, the metasedimentary rocks should face north. The numerous south facing determinations undoubtedly result from isoclinal folding within the metasedimentary rocks perhaps related to the strike-slip or thrusting along the Magpie River Fault.

North of the Magpie River, approximately half way to the long linear lake along which the metasedimentary rocks described above occur, is another wacke-siltstone argillite unit. This unit lies in sharp contact with coarse intermediate to felsic volcanic breccia. Abundant minor tight folding occurs in this unit near the contact. This folding is absent in the metasedimentary rocks around the long linear lake. The author considers it to be a local feature related to strike-slip or thrust faulting along the Magpie River Fault.

North of the Eleanor Iron Range and west of the Mildred Lake Fault, Neale (1981) completed a study of the lower part of the Eleanor Slates of the Dore metasedimentary rocks (Figure 34). Neale (1981) subdivided this section into 4 facies and 8 lithologies in a vertical section of 1700 m. The metasedimentary rocks are north-facing and lie on north-facing pillowed to massive mafic metavolcanic rocks of cycle two. A lack of exposure over a distance of 170 m separates the metavolcanic rocks from the metasedimentary rocks so the actual contact is not available for examination. On the basis of regional mapping, the metavolcanic metasedimentary contact is parallel to lithologic trends in both units.

The basal 200 m thick polymictic conglomerate unit contains clasts that range from 0.2 to 9 cm, average about 2 cm and consist of an estimated 35% felsic volcanic rocks, 30% mafic volcanic rocks, 15% sandstones, 10% reddish brown carbonate and 10% chert (Neale 1981 p.11). The unit is poorly bedded to massive, displays both matrix-and clast-supported sections with matrix-supported sections most abundant (Neale 1981, p.11). The clasts are subangular to subrounded and imbricated in the lower part but deformation prevents interpretation as to current direction (Neale 1981 p.11). The mafic clasts are more deformed than the felsic.

In thin section, the conglomerate contains 45% volcanic rock fragments, 15% mudstone, 15% carbonate, in a matrix of recrystallized sand-sized quartz, plagioclase, ferruginous dolomite, sericite and iron sulphides (Neale 1981, p.21). Neale (1981, p.21) interpreted the quartz-chlorite-sericite mineralogy of the matrix to suggest a mafic volcanic source due to its high chlorite content. The pyrite was considered to be authigenic. Minor mosaic-textured quartz aggregates from 0.13 to 0.8 mm are present as well as crosscutting polycrystalline quartz stringers up to 2 mm wide.

After a 20 m gap in outcrop, argillite-siltstone is encountered above the conglomerate. The argillite beds are 1 to 2 cm thick, the siltstone beds 1 to 3 mm thick and the beds display sharp upper and lower contacts (Neale 1981, p.12). Flame structures are present but rare and cross lamination is present in the argillite (Neale 1981, p.12).

Above the argillite-siltstone unit a talcose wacke horizon is present. Talc is present in grains up to 0.5 to 1 mm and magnesite forms approximately 10% of the rock (Neale 1981, p.12). Neale (1981, p.21) considered the talc and magnesite to be authigenic. The talc occurs as anhedral grains and fibrous subparallel aggregates. Subhedral rhombi of magnesite occur in a recrystallized groundmass of talc, quartz, sericite and ferruginous dolomite (Neale 1981, p.22). Some of the magnesite grains are rimmed with pyrite and limonite.

Above the talcose wacke is a quartz-dolomite wacke. This unit consists of quartz, ferruginous dolomite and chlorite 0.5 to 0.9 mm in grain size overprinted by coarse-grained carbonate (Neale 1981, p.12). The rock is poorly sorted and lacks primary structures (Neale 1981, p.12). Neale (1981, p.22) described the quartz-dolomite wacke rock as consisting of quartz, feldspar, patchy ferruginous dolomite, chlorite and white mica. The quartz occurs as angular to subangular polycrystalline aggregates with sutured grain boundaries and wavy extinction (Neale 1981 p.23). The plagioclase is An12 to An17 in composition and altered to sericite along grain boundaries and cleavages (Neale 1981 p.23).

A lack of exposure of approximately 75 m is present and then rhythmically interbedded siltstone-argillite is encountered which is similar to the previously described siltstone-argillite section. Neale (1981 p.13) described the siltstone beds as 2 to 5 cm thick

and more abundant than argillite beds which range from 0.2 to 4 mm thick. Neale (1981, p.13) notes an absence of flame structures and cross laminations and observed that the siltstones and argillites have well defined regular bedding with a sharp base.

Interlayered with the siltstone and argillite is a feldspathic wacke consisting of grains 1 to 3 mm in size (Neale 1981 p.18). The beds have a sharp base and may be normally graded. The unit contains untwinned (authigenic) and twinned (detrital) plagioclase, subordinate quartz, with minor to trace amounts of chlorite, ferruginous dolomite and pyrite (Neale 1981 p.26). The subhedral untwinned authigenic plagioclase is more abundant than the subangular detrital, twinned plagioclase (Neale 1981 p.26). Neale (1981, p.26) reported the plagioclase to be pervasively altered to sericite. Above the siltstone-argillite and feldspathic wacke lies an extensive section classified as subarkosic sandstone by Neale (1981, p.15).

In the upper part of this section, ripple cross laminations and trough cross-beds up to 40 cm deep are present (Neale 1981, p.15). The ripples are described as asymmetrical and suggest current flow from west to east. The degree of sorting is variable and two units of thick bedded chlorite-dolomite and quartz-fuchsite schist are present (Neale 1981, p.15). She described the chlorite as occurring in a carbonate-rich reddish brown matrix and the fuchsite as occurring in large (0.5 to 3 mm) grains in association with quartz.

In thin sections of the feldspathic wacke, subhedral untwinned (authigenic) plagioclase grains are more abundant than twinned subangular (detrital) grains. Samples lower in the section have more plagioclase and a larger grain size than those higher in the section (Neale 1981, p.26). She reported an anorthite content of An5 to An10 (Neale 1981, p.26). The polycrystalline nature of the quartz and the overprinting of the original mineralogy by ferruginous dolomite, sericite, chlorite and pyrite implies alteration and metamorphism of pre-existing material (Neale 1981, p.26).

Neale (1981, p.28) described the quartz-fuchsite schist as consisting of polygonalized aggregates of quartz and fuchsite-bearing microporphyritic rock fragments. She identified the green mica as fuchsite by X-ray diffraction techniques.

The chlorite-dolomite bands and polycrystalline aggregates are considered authigenic by Neale (1981, p.28) and the bands display a dendritic form. They rarely exist as solitary grains. Most quartz is described (Neale 1981, p.28) as polycrystalline and is contained with subangular to subrounded rock fragments. Neale (1981, p.28) described the rock fragments as being oriented subparallel to each other and enveloped in recrystallized chlorite and dolomite.

From bottom to the top of the section examined, Neale (1981) subdivided the stratigraphy into four facies. The lower conglomerate unit is interpreted to be an alluvial fan

debris flow deposit proximal to the volcanic source area (Neale 1981, p.39). The second facies is laminated argillite and siltstone with massive thick bedded wackes. This unit lies between 510 and 670 m in the section. It is interpreted to be a turbidite sequence in a distal setting (Neale 1981, p.41).

The argillites and siltstones are interpreted as interchannel deposits on an upper submarine fan and the massive greywackes are in-channel turbidity deposits (Neale 1981, p.42). The talc and quartz dolomite wackes are interpreted as "proximal exotic" deposits formed in lower canyon or upper fan channels but they can occur anywhere along fan margins that border basin slopes (Neale 1981, p.42).

The third facies occurs between 750 to 1300 m in the section and consists of regularly bedded, normally graded and feldspathic wackes and siltstone with sharp basal contacts which are interpreted to represent overbank (wacke) and in-channel (siltstone) deposition on the middle fan (Neale 1981 p.42).

The rocks are texturally immature and she considers the presence of talc to indicate ultramafic rocks in the source area.

The fourth facies is represented in the section by a subarkose from 1400 to 1625 m. The alternating cycles of ripples, megaripples and parallel laminations are interpreted by Neale (1981 p.45) to represent braided stream deposits in a proximal environment.

The decreasing plagioclase content and grain size upward suggests increasing maturity.

Neale (1981, p.48) concluded the provenance for the metasedimentary rocks was mixed. Neale (1981, p.48) suggested that the source for the quartz may be the quartz porphyries in the Arliss Lake area and that talc-magnetite wacke and fuchsite-bearing schists imply erosion and weathering of ultramafic rocks. The Arliss Lake quartz porphyries are limited in extent, cut the metasedimentary rocks in the lower part of the section. Consequently, these porphyries are considered by the author as not a likely source for the quartz in the wackes and arkosic rocks. As observed by the author and by Foster (1981) in other areas, the most likely source is easily eroded quartz-feldspar crystal tuffs associated with second cycle volcanism.

The only significant section of volcanic stratigraphy that could provide a significant ultramafic source for the talc is the lower part of first cycle volcanism or subcycle one. The conglomerate is a non-marine alluvial fan deposit which is separated from the non-marine alluvial fan environment of the subarkoses by an interval of marine deposition (Neale 1981, p.48). This suggests a period of rapid subsidence followed by uplift.

This postulated uplift may have proceeded a third cycle of volcanism if subsequent mapping north of the map area substantiates the presence of a cycle of volcanism above the metasedimentary rocks.

Marine deposition was below wave base and consists of thin-bedded argillite and siltstone turbidites deposited within and between channels on a submarine fan. Figures 35 and 36 are AFM and cation plots respectively for the Eleanor Slates. The data indicate considerable variation in present rock composition and high Mg contents of some samples.

The Mildred Lake Fault offsets the Eleanor Slates. They reappear north of the Lucy Iron Range north and east of Mildred Lake. Relative to the section west of the fault the quantity of subarkose to wacke east of the fault appears to be greater and the section thicker. Some of the thickening is due to strike-slip or thrust faulting that stacked and repeated the section. The section at Mildred Lake strikes eastward to the Bauldry Lake Fault where it is again faulted to the north. The wacke to arkosic component relative to siltstone-argillite appears to increase from west to east. By extrapolation, the non-marine facies of Neale (1981) increases from west to east and the marine portion decreases.

While Neale (1981) uses the term subarkose for these clastic rocks the author has used the term wacke since a significant chlorite content is present in the matrix. The subarkose or wackes weather grey, grey-white or buff but on fresh surface they are green to pale green. The green colour can be distinct and the rocks on fresh surface can easily be confused with those mafic metavolcanic rocks of a lighter green colour.

North of the Lucy Iron Range, primary structures are well-preserved. Excellent cross-bedding and soft sediment structures and rare ripple marks and flame structures are present. Mud-chip breccia, dewatering features and rare mudcracks are also present. The most useful structures for geological interpretation are in the coarser wackes. On the basis of ripple marks and cross-bed truncations, sediment transport is from west to east in a north facing sedimentary sequence. Pyrite cubes up to 1 cm may occur along bedding planes. These are interpreted as being diagenetic resulting from reduction, possibly by biological processes, of sulphate from interstitial waters. The subarkose or wackes north of the Lucy and Ruth Iron Ranges and extending northward to the Josephine Iron Range in Corbiere Township were mapped as felsic volcanic rocks by Moore and Armstrong (1946).

In thin section, the wackes are fine- to medium-grained seriate, granoblastic with curved grain boundaries. The mode is estimated (one sample) to be 30% carbonate, 35 to 40% quartz, 20% plagioclase and 20% sericite. Traces of opaques and biotite are present.

The quartz occurs as angular, anhedral, unstressed grains and the plagioclase occurs as angular to rounded grains that are moderately saussuritized. The carbonate is anhedral interstitial and the sericite is very fine-grained and imparts a schistosity to the rock due to its preferred orientation.

A thin section of an associated siltstone indicates a very fine-grained, seriate somewhat granoblastic texture. The rock consists of an estimated 30% plagioclase, 30% quartz, 10%

chlorite and 30% ragged acicular amphibole. The preferred orientation of the amphibole and chlorite imparts a schistosity to the rock. The angularity of the quartz and feldspar grains indicates a relatively immature sediment. The arkosic nature of the metasedimentary rocks reflects the tuffaceous volcanic source area and the lack of extensive reworking. A petrographic study of the wacke to subarkosic rocks by Ojakangas (1983, 1985) indicates a dominant, if not exclusively felsic volcanic source for the metasedimentary rocks, which is in agreement with field and petrographic observations by the author.

In support of geologic mapping in the Wawa area, Thomas (1984) completed a detailed examination of a stratigraphic section through the metasedimentary rocks above the Lucy Iron Range. The section studied faces north and is in conformable contact with intermediate to mafic metavolcanic rocks of cycle two volcanism. The top of the exposed section terminates against minor faults related to the Magpie River Fault, which have thrust similar appearing metasedimentary rocks above the studied section. The sequence of metasedimentary rocks north of the fault display both south and north facing data implying local folding accompanied faulting. This faulting has doubled the thickness of exposed metasedimentary rocks north of the Lucy Iron Range relative to the section studied by Neale (1981) west of the Mildred Lake Fault. The lower conformable contact has been interpreted as either a fault or an unconformity in the type section exposed at Michipicoten Harbour, west of the map area (Cooke 1937; Attoh 1981a, 1981b). A slight variation in strike of the rock units across the contact suggests an unconformity may exist at the lower metavolcanic-metasedimentary rock contact north of the Lucy Iron Range.

At the base of the studied metasedimentary section, approximately 5 m of argillite lies in conformable contact with the intermediate to mafic metavolcanic rocks of cycle two. The argillite is iron stained, contains pyrite and displays no visible internal structure (Thomas 1984, p.14).

Overlying and conformable with the argillite is a conglomerate-lithic sandstone facies. The conglomerate is polymictic, stratified, poorly sorted, dominantly matrix-supported and thin to thickly bedded (Thomas 1984, p.15). The clasts are dominantly rounded to subrounded in shape and vary from 0.2 to 20 cm in maximum length but average 2 cm; rare angular clasts up to 1 cm in size may also be present. The clast population consists of 75% banded chert, 20% felsic metavolcanic, 2% siltstone, 2% mafic metavolcanic and 1% argillite (Thomas 1984, p.15). The clasts were observed to be elongated in the plan of bedding and rarely display an imbrication (Thomas 1984, p.15). Tectonic flattening prevents the use of imbrication to determine direction of sediment transport.

Thomas (1984, p.15) reported: (1) the presence of weathering rinds on some clasts; (2) the presence of scour channels and (3) within individual beds the basal contacts are sharp

and there is a gradation upwards from conglomerate to lithic sandstone. The conglomerate at the base of the bed may be clast-supported grading upwards into a matrix supported framework. Normal grading of clasts and matrix is common and bedding appears rhythmic in some instances (Thomas 1984, p.16). Draping of silt and sand over clasts is common and one inversely graded bed was recognized (Thomas 1984, p.16) (Plates 18, 19, 20).

Between the conglomerate beds, thin to medium parallel bedded, massive to laminated lithic sandstone is present, which may be pebble-free but generally contains randomly scattered pebbles (Thomas 1984, p.16). Thomas (1984, p.16) reported concretions to be present in one bed.

The conglomerate matrix is dominantly recrystallized chert, quartz and rock fragments (Thomas 1984, p.15). Plagioclase feldspar is absent. In the area examined, Thomas (1984, p.16) estimated the conglomerate-lithic sandstone to be 60 m thick in the west and 18 m in the east.

Above the conglomerate lithic sandstone lies an intermediate to mafic metavolcanic unit which reaches a maximum of 50 m in thickness in the western part of his map area (Thomas 1984, p.19). The flow unit contains rare ovoid amygdules up to 2 mm locally composing 20% of the rock. The flow pinches out to the east over an estimated strike length of 380 m.

Lying above the intermediate to mafic flow, the Arnott-Wilkes Iron Range reaches a maximum width of 7 m and has a strike length estimated at 240 m. Drill records suggest this iron range interfingers with argillite (AFRO). The author has suggested that this iron formation may be a slump deposit (see the section in this report on iron formation).

Above the iron formation Thomas (1984) has identified another massive argillite unit identical to the one occurring at the base. The massive argillite appears conformable with the iron formation and displays a well developed northeast-striking cleavage (Thomas 1984, p.19, 20). He estimated this argillite unit to be approximately 10 m thick (Thomas 1984, p.20). Above the argillite is a horizon of pebble conglomerate lithic-sandstone (Thomas 1984). Thomas (1984, p.20) described this unit as of mixed provenance, poorly sorted, polymictic, massive, with a mud matrix. The framework locally approaches being clast-supported. The clasts range from 0.1 to 6 by 2 cm and average approximately 1.5 by 0.5 cm (Thomas 1984, p.20). Flattened pebbles display a long axis parallel to bedding. Thomas (1984, p.20) estimates the pebble population to be siltstone 65%, wacke 25%, mudstone 5% and chert 5%. The clast framework may comprise up to 75 volume % of the unit. The pebble conglomerate matrix is described by Thomas (1984, p.20) as consisting of sand-and silt-like particles with some authigenic pyrite present.

Within the conglomerate, there are no primary structures other than beds of lithic sandstone (Thomas 1984, p.20). The sandstones display a conformable contact with the overlying sandstone-siltstone and an erosional contact with the underlying siltstone (Thomas 1984, p.20). Thomas (1984, p.20) estimated that this conglomerate unit has a maximum width of 18 m.

Above the pebble conglomerate-lithic sandstone unit lies an estimated 125 m thick section in the west and a 24 m section in the east of siltstone-wacke. This unit overlies two different facies along strike, argillite and pebble conglomerate-lithic sandstone (Thomas 1984, p.21).

The unit is dominantly massive but locally rhythmic interstratification of thin beds is preserved (Thomas 1984, p.21). The thin beds were described as having sharp tops and bottoms. Graded bedding is rare. Thomas (1984, p.21) divided the siltstones into feldspathic wackes and lithic wackes.

Above the siltstone-wacke unit, a distinctive sandstone unit estimated by Thomas (1984, p.22) to be at least 360 m thick is cut off by strike-slip or thrust faulting. The lower part of the sandstone section is generally devoid of primary sedimentary structures, however, the upper part contains abundant structures. A discordancy in bedding attitude implies the possibility of an unconformity between the sandstone and underlying siltstone-wacke. This discordancy could also be due to tectonism and related deformation (Thomas 1984, p.22).

In the upper part at the section, trough cross-beds up to 30 cm thick and tabular cross-beds with tangential lower sets are common (Thomas 1984, p.22) (Plate 21). The structures observed by the author and Thomas (1984, p.22) are penecontemporaneous slump structures, climbing ripples, symmetrical ripples and mud chip rip-up clasts (Plates 21, 22, 23). One thin bed displayed flame structure was observed and rare desiccation cracks are present (Plate 24).

Minor beds or laminations of silt may be present; mudstone and lithic sandstone are rare (Thomas 1984, p.24). Thomas (1984) classified the sandstone as subarkose.

Thomas (1984, p.24) observed that the sandstones are composed dominantly of detrital quartz with subordinate albite twinned plagioclase (An₁₄ to An₁₆). The plagioclase is altered to sericite and the quartz has been recrystallized. Thomas (1984, p.24) estimated the sand matrix to comprise 1/3 to 1/2 of the total rock and to consist of recrystallized quartz, ferroan dolomite, sericite and minor pyrite plus chlorite. The matrix was considered by him to be dominantly non-detrital.

Thomas (1984, p.31) interpreted the high quartz content of the sandstones to indicate a granite source area, however the author considers the sandstones to be dominantly derived by reworking quartz-feldspar crystal tuffs common in second cycle intermediate to felsic

volcanism. The metasedimentary rocks and quartz feldspar crystal tuffs display good interfingering relationships north of the Magpie River.

Following detailed study of the stratigraphic section, Thomas (1984) proposed an environmental interpretation. Figure 37 is the stratigraphic column prepared by Thomas (1984) and a summary of his environmental interpretation is as follows:

1. The lowest part of the section consisting of argillite, conglomerate-lithic sandstone and iron formation is representative of submarine fan and basinal facies associations or alluvial fan and lacustrine facies associations. The environment is marine.
2. The argillite, pebble conglomerate-lithic sandstone, siltstone-wacke assemblage in the middle part of the section is a representation of a submarine fan facies characterized by debris flows and interbedded wackes and siltstones. The environment is marine.
3. The upper part of the section consisting of sandstone is interpreted to represent a sandy braided river deposit in a non marine fluvial-alluvial fan facies association. Thomas (1984) as did Neale (1981) previously recognized in the metasedimentary rocks a mixed provenance indicating a tectonically unstable environment. The lower stratigraphy indicates a deeper water marine environment while the a upper stratigraphy indicates at shallow water non-marine environment.

The sedimentary package examined by Neale (1981) and Thomas (1984) is different from the metasedimentary package found north of the Magpie River and south of Steep Hill Falls. These metasedimentary rocks represent a turbiditic marine sequence characterized by graded bedding, flame structure, dewatering structures and mud-chip breccias. The sections examined by Neale (1981) and Thomas (1984), while possibly deep water turbidites in the lower part are dominated by shallow water cross-bedded, ripple marked and penecontemporaneous slumped non-marine sandstones in the upper part. The cross-bedded ripple marked metasedimentary rocks interpreted as a braided stream facies by Neale (1981) and Thomas (1984) can be traced eastward from Arliss Lake, north of the Lucy, Ruth and Josephine-Bartlett Iron Ranges to the area of Siderite Lake in the southeast corner of Corbiere Township adjacent to the map area (Plates 25, 26, 27). The strike length of these shallow water sedimentary rocks is approximately 19 km. The stratigraphically higher shallow water sedimentary rocks appear to increase in volume to the east relative to the lower deeper water possibly turbiditic metasedimentary rocks. Limited paleocurrent direction determinations, based on asymmetrical ripples or cross-bedding relationships, are from west to east indicating that these shallow water metasedimentary rocks were interior to the basin where deeper water metasedimentary rocks should be expected. The stratigraphic thickness

of the overall metasedimentary package also decreases from west to east towards the proposed interior of the basin. The observations that the volume of shallow water metasedimentary rocks in the stratigraphic section increase eastward towards the interior of the interpreted Archean basin and that the overall thickness of metasedimentary rocks decreases eastward may place some restrictions on basin modelling. The coarse boulder conglomerates to the west of the map area and the presence of finer-grained clastics to the east combined with limited west to east paleocurrent directions would suggest that deep water sedimentary rocks should increase in volume to the east. The opposite trend is observed suggesting the possibility that uplift and erosion of deeper water sediments preceded shallow water deposition. The metasedimentary section north of the Lucy Iron Range has been doubled due to strike-slip or thrust faulting and this style of faulting can be inferred to have affected the metasedimentary section throughout its strike length from Arliss Lake in Chabanel Township to Siderite Lake in Corbiere Township. At no place along the strike length of this metasedimentary unit, is there a tectonically undisturbed section where reliable estimates of original thickness can be determined or unsheared upper and lower contacts examined. The presence of desiccation cracks within the sandstone unit provides some strong evidence the second cycle intermediate to felsic volcanism was partly subaerial.

FERRUGINOUS DOLOMITE

A rusty brown weathering fine-grained ferruginous dolomite with sharp upper and lower contacts is situated below the felsic part of cycle one metavolcanic rocks and above the mafic breccia capping the intermediate to mafic metavolcanic rocks. This unit forms a distinctive marker horizon approximately 250 m below the Ruth Iron Range and extends to the east end of the Josephine-Bartlett Iron Range in Corbiere Township. The unit is highly variable in width varying from zero to over 66 m at Siderite Lake, Corbiere Township, adjacent to the map area. The unit is criss-crossed on the weathered surface by milky quartz stringers and veins. The most prolific development of quartz veining in this unit occurs in the cliff face south of Parks Lake in Corbiere Township. Below the Ruth Iron Range approximately 33 m of ferruginous dolomite are overlain by a polymictic breccia that contains rounded clasts up to 0.5 m in size derived from the underlying dolomite. Dr. Donaldson (Carleton University, personal communication, 1981) has recognized possible stromatolitic structures in ferruginous dolomite clasts within the polymictic breccia. The base of the unit is thinly laminated but most of the unit is massive and lacks primary structures. The overlying polymictic breccia cannot be traced laterally and likely represents a channel fill deposited in a channel eroded into the dolomite. Laterally, from the breccia the presence of

fine- to medium-grained, graded, thinly bedded intermediate to felsic tuffs indicate that the metavolcanic rocks directly overlying the dolomite have been reworked. In the Siderite Lake area, the dolomite is overlain by thin bedded fine-grained, intermediate to felsic tuffs. The dolomite unit represents a period of extensive carbonate and minor silica deposition that proceeded carbonate deposition associated with the Michipicoten Iron Formation. Excellent exposures of this unit are present below the Ruth Iron Range east of the south end of Bauldry Lake, in a railway cut on the Algoma Central Railway at Leg Lake below the Ruth Iron Range, in the cliff face on the south side of Parks Lake, Corbiere Township and below the Josephine Iron Range and south of Siderite Lake, Corbiere Township, below the Bartlett Iron Range. At the west end of the Ruth Iron Range, the dolomite lies on an intermediate to felsic lapilli tuff but at the east end it lies on mafic lapilli tuff possibly correlative with the mafic breccia on the south shore of Brooks Lake below the Lucy Iron Range. The ferruginous dolomite lies on top of the mafic breccia for the remaining distance that it can be traced to Siderite Lake in Corbiere Township. This unit is traceable for approximately 10 km.

In thin section, the unit is fine-grained, equigranular, massive, allotriomorphic with lobate grain boundaries.

The rock consists of 90 to 95% carbonate forming an interlocking mosaic. The quartz occurs as aggregates of fine-grains and as fracture fillings. The presence of this unit in the volcanic stratigraphy suggests the possibility that volcanic fumarolic activity may have played a role in its formation and its deposition may have been accompanied by some biological activity. If the presence of stromatolites can be confirmed, a shallow water environment can be inferred prior to the onset of iron formation deposition that caps the intermediate to felsic metavolcanic rocks of cycle two.

IRON FORMATION (MAP UNIT 5)

Iron formation is well-developed and its exploitation has been the greatest source of mineral revenues for the Wawa area. The recovery of iron began in approximately 1900 and continues to the present. Nearly all of this iron production has come from iron ranges located in Chabanel Township. As a consequence of its economic importance, the iron formation has been the subject of numerous reports.

The author uses the term "iron formation" in the same sense as previous authors writing on the Wawa area. The Michipicoten iron formation represents a mixed package of chemical and clastic metasedimentary rock found in association with rocks of volcanic origin. The Michipicoten iron formation ranges from iron-rich to essentially iron-free units. The

contacts of the facies are gradational and sharp internal breaks or contacts are generally not present. Previous workers recognized three facies of iron formation within the Michipicoten-type iron formation: carbonate, sulphide, chert (Collins and Quirke 1926, p.71; Grout 1926, p.815; Hawley 1942, p.79; Moore and Armstrong 1946, p.4; Young 1953, p.19 Canadian Mining Journal 1956, p.81; Goodwin 1962, p.573, 1964, p.681, 1966, p.63; Goodwin and Shklanka 1967, p.787;). In the present work, Michipicoten iron formation is divided into a minimum of five facies that occur in a consistent pattern. Each facies varies greatly in degree of development at locations along strike. The five facies recognized are carbonate (dominantly siderite), sulphide (dominantly pyrite), chert-magnetite, chert-wacke and argillite-graphite-pyrite. The best developed facies is the chert-rich facies which due to its resistance to erosion forms prominent topographic ridges within the volcanic stratigraphy. No systematic development of one facies over another occurs along strike within the present map area.

The iron formation has been broken up into segments by northwest striking left-lateral faulting and these fault bounded segments are referred to as ranges consistent with historical usage. In the iron ranges south of the map area, Massey (1985, p.18) reported the presence of grunerite. This mineral was not identified by the author in the present map area.

CARBONATE FACIES

Carbonate facies always occurs at the stratigraphic bottom of the Michipicoten type iron formation and if recognized in the field the facing directions of the enclosing metavolcanic rocks can thus be easily determined. It is composed dominantly of siderite however, Collins and Quirke (1926, p.64); Goodwin and Shklanka (1967, p.787) Richter (1952, p.22) reported the presence of Ca-Mg-and Mn-carbonates. The carbonate unit lies in sharp contact with the underlying fragmental rocks which are commonly, but not always intermediate to felsic metavolcanic rocks. This lower contact has been interpreted to be gradational with the underlying tuffs (Collins and Quirke 1926, p.63; Tanton 1948, p.424; Grout 1926, p.815; Kidder and McCartney 1946, p.14; Richter 1952, p.22) however, excavation of the Lucy Pit, Lucy Iron Range has exposed the siderite-metavolcanic contact and it is knife-edge sharp. Eden (1980) recently described this contact and Young (1951, p.39; 1953, p.33) had previously recognized a sharp lower contact during diamond drilling of the Lucy Iron Range. Goodwin (1961, p.26; 1962, p.578; 1964, p.709) recognized a sharp basal contact with the underlying metavolcanic rocks at the Helen Iron Range on the basis of abrupt changes in the rock chemistry. The lower contact at the Helen Iron Range was the one examined and interpreted as gradational by earlier investigators. The presence of

nodules of siderite in the underlying tuffs have been used to postulate a gradational lower contact (Richter 1952, p.86; Kidder and McCartney 1942, p.15) but are interpreted by Young (1951, p.40 1953, p.33) to be boudinaged siderite fragments that resulted from deformation along the siderite-metavolcanic contact. The Helen Iron Range footwall rocks have been subjected to considerable deformation and the footwall rocks at the Lucy Iron Range where Young (1951) completed most of his work are very fissile implying deformation. The author concurs with Young's (1951, 1953) interpretation that siderite nodules within the lower tuffs are likely boudinaged fragments and the carbonate iron formation lies in sharp contact with the metavolcanic rocks. Earlier investigators did not recognize the sharp contrast in carbonate composition between the siderite facies and the ankerite-bearing underlying metavolcanic rocks leading to the interpretation of a gradational contact. In fresh drill core, this would be a problem, however, a sharp contrast exists in the weathering of the siderite versus footwall tuffs at the Lucy Iron Range. The siderite weathers a deep chocolate brown and the carbonatized lower tuffs a light orange brown. Young (1951, p.40) recognized the difference in carbonate composition and considered the carbonate of the footwall rocks to be mostly ankerite. Minor siderite in association with the ankerite has been described in the alteration mineral assemblages at the Josephine Iron Range immediately north of this project area (Lockwood 1983).

At the Helen Iron Range, a chert horizon, identical to the chert forming the upper part of the iron range lies between the siderite and footwall volcanic rocks (Kidder and McCartney 1946, p.14; Canadian Mining Journal 1956, p.83; Goodwin 1964, p.692). This chert unit is known as the lower banded iron formation and is not present at the other iron ranges. This chert unit varies from 1 to 10 m in width (Goodwin 1964, p.692). Also within the carbonate facies at the Helen Iron Range is an internal coarse-grained structureless chert unit known as the central chert or silica that varies from 0 to 20 m in width (Kidder and McCartney 1946, p.14; Canadian Mining Journal 1956, p.84; Goodwin 1964, p.692).

Shale and pyrite-bearing rock is reported by Goodwin (1964, p.692) to occur with the lower banded iron formation. The presence of a siliceous argillite unit 13 m (40 feet) above the lower banded iron formation is reported by the Canadian Mining Journal (1956, p.84). This argillite unit is 1.5 m in width, thin bedded with pyrite and pyrrhotite layers and gradational into overlying siliceous siderite (Canadian Mining Journal 1956, p.84).

The presence of some of the chert and argillite units at the Helen Iron Range and their absence from the other iron ranges may be the result of tectonic activity related to movement along the Talbot Lake Fault which has tectonically thickened, folded, stacked and faulted the Helen Iron Range.

Fresh unweathered siderite is buff coloured, breaks with a subconchoidal fracture and is easily mistaken for a fine-grained, massive felsic metavolcanic rock except for its high density. The average carbonate grain size is 0.05 mm (Young 1953, p.34) and varies between 0.003 and 0.07 mm (Richter 1952, p.59). Richter (1952, p.59) reported that the C-axes of the carbonate grains display a preferred orientation and that cataclasts is present in some thin sections of the carbonate facies. The dark chocolate brown weathering of the siderite makes field recognition easy. The siderite is commonly dusted with fine-grained euhedral pyrite at the base of the unit and as one moves up section pyrite becomes increasingly more abundant as the sulphide facies is approached. The siderite is structureless at the base, but the siderite displays increasingly better lamination up the stratigraphic section. The sulphide in some stratigraphic sections forms thin layers that may be less than 1 mm in thickness and have the appearance of cryptoalgal mattes.

At the base of the carbonate facies of the Lucy Iron Range, arsenopyrite is abundant and decreases in volume upward to the sulphide facies. The dominant mode of occurrence of arsenopyrite is as euhedral, doubly terminated, prismatic to needle-like, single and twinned crystals up to 5 cm in length disseminated in massive, fine-grained siderite. These doubly terminated crystals appear to have grown in the siderite before it lithified since they lack points of attachment or the appearance of occupying former openings. Arsenopyrite and pyrite crystals occur in quartz stringers cutting the siderite and are larger and more blocky than those found within the siderite immediately marginal to the veins.

Young (1953, p.34) reported the presence of minor pyrrhotite in the siderite and that the arsenopyrite and pyrite within the siderite are later in paragenesis than the enclosing carbonate. Young (1951, p.46) interpreted the arsenopyrite to be a hydrothermal replacement of the siderite but did not explain how such replacement would generate randomly oriented crystals sprinkled throughout the siderite in contrast to expected masses of arsenopyrite. The author considers the

As one moves up the stratigraphic section, in addition to pyrite banding, thin beds and laminae of chlorite, silica and sericite impart an increasingly more visible bedded appearance to the carbonate facies. Near the base of the carbonate facies, Collins and Quirke (1926, p.63) reported the presence of volcanic rock fragments completely replaced by siderite; the number and size of which decrease upward. Microscopic rock clasts are reported to occur throughout the siderite (Goodwin 1962, p.578) and chlorite clots or shreds have been described by Collins and Quirke (1926, p.69) and Richter (1952, p.60). In addition, Collins and Quirke (1926, p.69) reported the presence of chloritoid crystals occurring in streaks and as individual grains within the siderite.

Eden (1980, p.27) and Abercrombie (1981, p.58) identified plates of sericite, irregular patches of sericite and chlorite and small aggregates of fine-grained quartz in the carbonate facies of the Lucy Iron Range.

Slabbed and polished samples of carbonate and sulphide facies iron formation commonly contain angular to subangular rock clasts completely replaced by iron carbonate or sulphide. This observation combined with the presence of aggregates of sericite or chlorite or sericite-chlorite indicates that clastic volcanic debris was introduced into the iron formation during deposition. This material is thought by the author to have been washed into the depositing iron formation by submarine currents or represent wind-blown volcanic material deposited on the water surface and subsequently settled to the bottom where it was incorporated into the developing iron formation. Most of the polycrystalline quartz aggregates are likely recrystallized chert deposited along with the iron carbonate, but some may represent relict quartz fillings of amygdulites in replaced volcanic rock fragments.

An excellent exposure of carbonate facies iron formation occurs at the west end of the Lucy Pit, Lucy Iron Range.

SULPHIDE FACIES

Grading stratigraphically upward from the carbonate facies is the sulphide facies. The sulphide facies grades upwards into a chert-magnetite-wacke facies. This facies shows an increasing sulphide content as one moves stratigraphically upward. Silica, to a much smaller degree, also increases upward. The sulphide sometimes occurs in thin layers, often associated with ovoid structures up to 4 to 6 mm in diameter. These thin layers, commonly 1 mm or less in thickness, have the appearance of cryptoalgal mattes. The sulphides are also commonly present as ovoid or elliptical masses up to 2 to 3 cm in length along the long axis; other sulphides appear to be bulbous masses of branching and interlocking masses whose interstices are filled with siderite and perhaps minor silica. Where the sulphide facies becomes massive and other minerals comprise only a minor component, the sulphides are fine-grained, granular and lack development of delicate structures. Richter (1952, p.22) suggested that the sulphide unit rarely exceeds 90% sulphide with the remainder mainly carbonate and silica. Collins and Quirke (1926, p.70) indicated that the sulphide is 90% pyrite and 10% pyrrhotite. The sulphide facies is only developed to a limited extent in the present map area when compared to the Goudreau area (Collins and Quirke 1926; Bruce 1940) to the northeast of Wawa where thick units of sulphide facies iron formation are present.

The sulphides occurring as ovoid or branching bulbous masses commonly display dull-weathering cores and a thin 1 to 2 mm thick rim of bright shiny pyrite. In those areas of the sulphide facies with a high matrix content, the sulphides may be disseminated throughout the carbonate, or siliceous carbonate matrix as euhedral crystals to anhedral grains generally 1 mm or less in maximum dimension. Young (1953, p.28) reported that some megascopic pyrite grains form crude ovoid structures with siliceous carbonate cores that commonly interlock creating a lacy pattern.

Sericite grains were observed to bend around pyrite grains. Carbonaceous material, chlorite and carbonate are present in association with the sulphides (Young 1953, p.28, 29). The bending of the sericite grains around the pyrite grains has been interpreted to indicate that it formed prior to deformation (Young 1953, p.29), however, this feature could also result from the inheritance of a primary fabric resulting from recrystallization and alteration of volcanic ash material that accumulated around the sulphide grains at the time of formation.

Study of the ovoid sulphide structures by Young (1953, p.30) indicate that they overlap with one another and may be crosscut by later vein material. Pyrite layers, sericite grains and silica layers bend around the spheres (Young 1953, p.30). The cores of the spheres in thin section are an aggregate of quartz plus sulphide; moving outward, quartz increases and sericite is present (Young 1953, p.30). The ovoid structures display a radial pattern of sericite, sulphide and quartz minerals and a rough concentric banding is present in some spheres (Young 1953, p.30). On weathered surfaces, a concentric and radial pattern is often visually apparent in broken ovoid structures. Sericite within the spheres is coarser-grained than sericite outside the sphere and the silica inside the sphere is dusted with carbonaceous material (Young 1953, p.30). On the outer edge of the spheres, pyrite occurs with good crystal faces, however, the inner surface is a smooth curve (Young 1953, p.31). If the pyrite crystal face is lacking, sericite is present which is oriented parallel to the ovoid surface, Young 1953, p.31).

Young (1953, p.31) reported that pyrrhotite may form the cores to spheres but becomes disseminated towards the periphery. The pyrrhotite has been interpreted to have replaced pyrite, quartz and sericite. It also appears to cut across the sphere boundaries (Young 1953, p.31). The ovoid structures were classified as granules by Young (1953, p.31-32), however, a few could be classified as oolites or pisolites due to their radial and concentric internal structure.

The sericite within the granules is unoriented which contrasts sharply with the oriented sericite external to the ovoids (Young 1953, p.32). The sericite relations suggested to Young

(1953 p.321) that the pyrite formation precedes deformation. The pyrite in the granules appears identical to that outside the granules (Young 1953 p.32).

Richter (1952, p.64) reported that the pyrite grain size ranges from 0.8 to 0.01 mm in diameter and that within the sulphide member of the iron formation the pyrite is granular. Within the chert-rich and carbonate members, the sulphide was reported to be dense and massive. In the carbonate member, the sulphide occurs as fine-grained lenses and stringers and in the chert-rich facies it occurs as bands parallel to the chert-carbonate beds (Richter 1952 p.65).

Richter (1952 p.64, 65) interpreted the pyrite-pyrrhotite relations to indicate that pyrrhotite replaced pyrite. He reported that pyrrhotite occurs in vein-like segregations up to 1.6 m in width within the sulphide facies at the Ruth Iron Range but that it generally forms less than 10% of the sulphide member.

Angular to subangular volcanic clasts, some of lapilli size, replaced or partly replaced by sulphide are common in polished surfaces of slabbed sulphide facies iron formation. Abercrombie (1981, p.59) reported that sericite occupies the interstices of some of the pyrite-rimmed lapilli and that some fragments appear deformed.

Eden (1980, p.27) found that the sulphide layers consisted of fine-grained pyrite crystals, quartz and siderite. Some bedding lamellae associated with the sulphides consist of a fine-grained mixture of quartz and sericite (Eden 1980 p.28). Angular to rounded volcanic fragments up to lapilli size are present consisting of quartz, sericite and siderite which are rimmed with anhedral fine-grained pyrite (Eden 1980, p.28). The replaced volcanic fragments may now consist of disseminated to massive clots of pyrite occur both as discrete fragments in association with pyrite-bearing siderite or as fragment-rich laminated beds (Eden 1980 p.28). The fragment matrix consists of fine-grained chert, siderite and sericite. The volcanic fragments are deformed and elongated and the bedding lamellae may be disrupted in these fragment-rich intercalations.

Most of the silica or chert was likely deposited along with the carbonate and sulphide even though some may be relict after chert fillings of vesicles in replaced volcanic rock fragments. The sericite, chlorite and some of the quartz found in the sulphide facies is of clastic origin having been washed or settled into the iron formation.

Good exposures of sulphide facies iron formation occur at the west end of the Lucy Pit, Lucy Iron Range.

CHERT-MAGNETITE-WACKE FACIES

Moving up stratigraphy thin discontinuous chert layers begin to appear. The chert layers alternate with layers of pyrite or siderite or pyrite-siderite. With the appearance of chert layers thin beds of magnetite and wacke make an appearance. This facies of iron formation is thin bedded and the sugary textured white, grey or buff chert bands may display diffuse thin laminations (Plate 28). The laminae in the chert are 1 mm or less in thickness. Individual beds or layers of chert, wacke, magnetite, sulphide or siliceous siderite commonly vary from 1 cm to 6 cm in width even though thinner and thicker beds do occur. The siderite bands are very siliceous but readily separable from the siderite-free beds by their rusty brown weathering. The siliceous siderite texturally resembles massive siderite with a mosaic of grains 0.04 mm in size with coarser quartz polyhedra (Eden 1980, p.31). Narrow zones of quartz define a laminated appearance.

The wacke layers are composed of fine-grained angular to subangular fragments of volcanic rock most likely derived from tuffaceous deposits. Clasts up to 1 cm have been seen in the wacke beds but most do not exceed a maximum dimension of several millimetres. The wacke layers may display grain gradation which indicate facing directions agreeing with facing directions found in the metavolcanic rocks above and below the iron formation. The magnetite beds occur in widths up to 1 cm and consist of massive black magnetite with a bright lustre on fresh surface. Pyrite is minor or trace and occurs only in the most magnetite-rich material. It is uncertain whether the magnetite is of clastic or chemical origin since it is interbedded with both clastic (wacke) and chemical (chert or siderite) metasedimentary rocks. The possibility that the magnetite is a diagenetic product of some unknown iron-rich mineral is conceivable.

The presence of thin bedded chert, wacke, magnetite and siderite in such close association negates regional metamorphism as a means of forming magnetite from siderite. The close association of magnetite beds with siderite beds separated by a few centimetres or less would require very unusual conditions of regional metamorphism to convert some siderite beds to magnetite but leaving adjacent beds untouched. The origin of the magnetite is a problem warranting additional work, but the author suspects it was deposited as magnetite or became magnetite very soon after deposition. Young (1953, p.23) considers at least some magnetite to be a replacement of siderite, however, the uniform thickness and conformable nature of the magnetite beds imply a primary origin.

In the lower part of this facies, at the Helen Iron Range, magnetite and siderite occur in close association. Collins and Quirke (1926, p.75) interpret the magnetite to result from the conversion of siderite to magnetite under subaerial conditions and that it is not caused

by either dynamic or contact metamorphism. As previously stated, the presence of thin siliceous siderite beds alternating with iron oxide and wacke layers suggests to the author either a detrital origin or an early diagenetic product of an unknown iron-rich compound. The presence of thin wacke beds displaying good grain gradation indicates subaqueous not subaerial conditions.

Richter (1952, p.19) also considered the magnetite to have replaced siderite but does not state the reasons for this interpretation.

Individual beds of chert-magnetite wacke pinch out across an outcrop and branching or splitting layers have been observed by the author.

Thin sections of the chert and siderite beds display a granoblastic texture (Young 1951, p.28) and have a grain size on the order of 0.07 mm (Young 1953, p.22). Young (1953, p.29) reported that the pyrite laminae contain more silica than the siderite laminae.

CHERT-WACKE FACIES

Continuing up the stratigraphic section magnetite and pyrite beds decrease in number and width and the iron formation becomes a thin bedded unit of chert and wacke with occasional pyrite. The chert bands are white, grey to dark grey and sometimes black near the upper part of this facies. The colour is the result of an increasing graphite or carbonaceous content as one goes up the stratigraphic section. The chert is commonly thinly laminated and has a sugary texture. The fine chert laminations within individual chert layers within this facies and in the lower facies have been attributed to seasonal variations in depositional conditions by Goodwin (1964, p.713). Some chert beds do not appear laminated and have the appearance than the laminated beds of quartzite. These beds are thicker and more massive in appearance and occur in the upper part of this facies. As with the chert-magnetite wacke facies, the intervening wacke layers are composed of clastic volcanic rock and chert and may display excellent grain gradation. Individual beds may pinch out along strike and more rarely they may split. The pinch and swell nature of the beds is typical of the chert-magnetite wacke and chert wacke facies. Individual beds vary from barely perceptible to approximately 10 cm in width. Eden (1980, p.29) described the chert in thin section as having granoblastic texture with good triple junction grain boundaries. He reported a average grain size of approximately 0.075 mm up to a maximum of 0.2 mm. He also reported that pyrite and siderite occurs in the chert along planar features concordant with bedding and when subjected to weathering, these iron-rich minerals cause the chert to be stained a yellow brown. Grey chert bands contain unoxidized siderite or pyrite. Richter (1952, p.20) reported a grain size of 0.4 mm to 0.8 mm for the polygonalized chert. The

chert containing the iron minerals occurs in an appreciably smaller grain size, on the order of 0.02 mm. Richter (1952, p.20) also reported the presence of white mica (sericite?) in the siderite chert.

In the upper part of this facies, as the carbonaceous and pyrite content increases, the carbonaceous films occur along the quartz grain boundaries which display cusped and embayed margins (Eden 1980, p.30). Patches of bleached-appearing white and grey chert display a subtle Liesegang rings [secondary, nested rings or bands caused by rhythmic precipitation within a fluid-saturated rock, (American Geological Institute 1987, p.378)]. This effect parallels the cusped grain margins (Eden 1980, p.30). This observation suggests that leaching occurred in the central part of some layers by a solution front (Eden 1980, p.30). Within the carbonaceous zones, Eden (1980, p.30) described ovoid structures up to 0.3 mm in maximum dimension flattened parallel to bedding. He described the ovoids as consisting of fine-grained quartz with interstitial carbonaceous coatings set in a matrix of carbonaceous chert.

The content of carbonaceous material consistently increases upward in the iron formation. Goodwin (1962, p.575) reported carbonaceous zones at the base and in the centre of the Helen Iron Range. His observation is more or less restricted to the Helen Iron Range and may be the result of tectonism that repeated some units and thickened the Helen Iron Range. Goodwin (1962, p.575) described the banded chert as containing layers of black carbonaceous shale up to 10 m thick and up to 30 m long. These carbonaceous units were described as being composed of fine-grained chert and amorphous carbon. The units contain pyrite and pyrrhotite; as thin discontinuous lenses, layers and streaks; as concretions and as scattered-grains. Goodwin (1962, p.575) also reported thin concordant streaks of chalcopyrite and sphalerite in these carbonaceous units.

Excellent exposures of the chert-wacke facies occur at the Helen and Lucy Iron Ranges (Plates 30, 31).

ARGILLITE-PYRITE-GRAPHITE FACIES

The black carbonaceous chert grades into fine-grained, fissile, pyrite-bearing graphitic argillite which lies in sharp contact with the overlying mafic flows of cycle two volcanism. Pyrite occurs as concentrations of euhedral to subhedral crystals parallel to bedding, disseminated grains in the chert and discontinuous lenses or layers resembling cryptoalgal mattes. Continuing up section the silica or chert content decreases and the rock becomes a carbonaceous argillite. In addition to the sprinkling of disseminated euhedral pyrite and cryptoalgal matte pyrite, the sulphide also occurs as oval concretions up to 4 to 5 cm in long

dimension. The concretions display both a concentric and radial morphology with the core sulphide having a dull lustre and the rim a bright luster. The surface of the concretion displays euhedral crystal faces of pyrite which is coated with carbonaceous material. The concretions may have several concentric layers but generally no more than three. Some of the larger concretions display an oval core up to 1 cm in maximum dimension which, is enclosed in a shell of radially oriented pyrite. This shell lacks a concentric zoning. The shell of radiating pyrite is then followed by an external shell of brighter lustred pyrite that displays euhedral external crystal faces. This shell may range from less than 1 mm to several millimetres in width. The best exposure of this facies of iron formation is located on the north side of the Sir James pit, Eleanor Iron Range (Plate 29).

BRECCIATED IRON FORMATION

Internal to the chert-magnetite wacke and chert-wacke facies of iron formation are conformable units of breccia. The author has observed these units to exceed 2 m in width, however, Richter (1953, p.23) on the Lucy Iron Range and Kidder and McCarthy (1946, p.13), on the Helen Iron Range, reported breccia units approaching 20 m in width. Goodwin (1962, p.575) reported the breccia units at the Helen Iron Range to be 10 m in width. The breccia zones occur between zones of unbrecciated iron formation and several zones of brecciated iron formation may alternate with zones of unbrecciated iron formation in a single outcrop. This observation is consistent with a primary origin for the breccia; a conclusion also reached by Goodwin (1962, p.575); Canadian Mining Journal (1956 p.84); Tanton (1948, p.424); and Young (1953, p.24). The breccia clasts consist of flat or tabular, angular to subangular fragments of laminated chert up to 0.3 m in maximum length. Only rarely is a weak imbrication present which suggests that the breccia is chaotic. The breccia clasts lack fragment size gradation. The breccia matrix consists of pyrite, chert, siderite, or wacke. The matrix represents the original rock units interbedded with the chert. Stratigraphically lower in the iron formation, the matrix is siderite or pyrite or both and often appears to have been remobilized as it fills fractures in the chert. The pyrite filling the fractures displays a brighter lustre than the pyrite forming the bulk of the iron formation. These apparent crosscutting relations have undoubtedly contributed to replacement theories for the origin of the iron formation. Higher in the section the breccia matrix is largely dark grey wacke.

The sharp angular corners to the clasts preclude any significant transport and indicate that the chert was lithified at the time of breccia formation while the intervening clastic beds were not.

Collins and Quirke (1926 p.75) interpreted these breccias to be the result of exposure of the chert to the atmosphere. The breccias, however, are conformable to undeformed breccia layers and lack significant crosscutting features such as channeling and scouring which one would expect if exposed to the atmosphere. This observation in combination with interbedded wackes displaying good grain gradation effectively eliminates a subaerial environment of formation.

Young (1953, p.25) proposed that the brecciation took place by wave action or by slumping during earthquake activity. He proposed a low water stage or one of violent storms.

Richter (1953, p.87) proposed that brecciation resulted from either contemporaneous deformation or to shrinkage during diagenesis.

Goodwin (1962, p.575) attributed the intraformational breccia to wave action.

The author rejects the possibility of wave action or excessively shallow water to generate the breccia. The well-developed grain gradation in the wacke layers in the undisturbed layers suggests that the presence of turbidity currents of probable random timing depositing clastic debris below wave base. The presence of any significant wave action would destroy such fine depositional features. Intervening chert deposition would protect the wacke layers from erosion by later currents. The chert lithified and likely become relatively impermeable more rapidly than the enclosing wacke or chemical sedimentary rocks which remained fluid saturated and potentially-unstable. Earth tremors would be expected in the volcanic environment which would trigger mass movement on the paleoslope existing at the time of iron formation deposition. One of the fluid saturated layers acted as a décollement and the resulting slump fragmented the lithified chert and mixed it with the unlithified fluid-saturated material occurring in adjacent beds. The process apparently repeated itself many times to generate the concordant breccias separated by relatively undisturbed zones.

Brecciated breccia occurs on the Helen Range and Young (1953, p.25) reported two ages of brecciation at the Sheldon, Central Brooks and West Brooks iron ranges in Corbiere Township north of the map area. The matrix for this brecciated breccia was described as silica by Young (1953, p.25) and at the Helen Iron Range it is mixture of silica and rock fragments. The author considers this breccia to result from a tectonic overprint superimposed on a primary breccia; a conclusion also reached by Young (1953 p.25).

IRON FORMATION - QUARTZ VEINING

In the well exposed face of carbonate, sulphide and chert iron formation at the western end of the Lucy pit, Lucy Iron Range a number of subhorizontal quartz veins cut the

carbonate and sulphide facies of iron formation. These veins reach a maximum width of 10 cm and do not extend below the carbonate facies iron formation into the underlying metavolcanic rocks. The veins extend through the sulphide facies iron formation, which is of limited development, into the area of the iron formation where distinct white to grey chert beds make their appearance. Thin section study of the chert or banded silica by Eden (1980, p.31) indicated the chert is cut by innumerable quartz veinlets which are commonly associated with microfaults in the banded chert. Eden (1980, p.31) also reported the presence of concordant quartz veins and discordant zones of breccia consisting of angular chert fragments in a quartz matrix.

The observations that these veins do not extend beyond the iron formation and that they are better developed in the lower carbonate and sulphide facies implies a relationship of the veins with the deposition of the iron formation. The iron formation is now subvertical in attitude so the presently subhorizontal veins would become subvertical if the iron formation was rotated back to the subhorizontal. It is unlikely that the iron formation was deposited in a perfectly horizontal position but it is impossible to approximate the dip of the paleoslope. The presence of intraformational chert breccias alternating with undeformed chert breccias strongly implies the presence of a slope at the time of deposition which permitted the slumpage required for breccia formation.

The siderite is recrystallized and coarse-grained next to the veins and upon weathering has a darker brown colour than the typical fine-grained aphanitic massive siderite of the iron formation. This feature suggests that the vein forming fluids were sufficiently hot to recrystallize the adjacent siderite forming a thermal aureole along the margins of the vein. The veins contain coarsely crystalline dark brown weathering siderite, light brown weathering ankerite and coarsely crystallized euhedral pyrite and arsenopyrite. Arsenopyrite in the siderite marginal to the vein is present in crystals larger than these found in the fine-grained aphanitic siderite. The arsenopyrite in the veins and immediately marginal to the veins has a tendency to be short and stubby in contrast to the needle-like prismatic crystals in the fine-grained siderite away from the veins. The pyrite, arsenopyrite and coarse-grained carbonate of the veins may have been remobilized from the iron formation.

The vein attitude and restriction to the lower part of the iron formation suggest to the author that they may represent fractures in lithified siderite that served as channels for hot silica-bearing fluids that transported silica to the surface where it precipitated forming the banded silica beds of the upper part of the iron formation. One cannot discount the possibility that veining is related to the regional deformation-metamorphic event and their restriction to the lower part of the iron formation is a function of the mechanical properties of rocks forming the iron formation.

Richter (1952) investigated the quartz veins within the iron formation. In addition to the minerals reported by the author, Richter (1952, p.67) reported chalcopyrite, galena and sphalerite and that the veins may be up to 1 m in width. Richter (1952, p.70) reported that the ankerite within the veins is magnesium-rich. These quartz veins are similar in appearance and minor mineral content to the gold-bearing veins found in the Wawa region (Richter 1952, p.67). The veins examined by the author, however, are restricted to the iron formation and are interpreted to have an origin related to development of the iron formation. Richter (1952, p.72) observed that the veins may change their minor mineral content along strike where they cross carbonate they are carbonate-rich; where they cross pyrite they are pyrite-rich. Richter (1952, p.72) interpreted the change in vein mineralogy to position in the iron formation as suggesting that the vein mineralogy was remobilized from the enclosing rock.

Pyrrhotite is reported as the most abundant sulphide in these late veins (Richter 1952, p.73) where it occurs as irregular stringers and masses replacing earlier vein pyrite and arsenopyrite. Younger chalcopyrite and sphalerite replace the pyrrhotite.

The pyrite is later than the arsenopyrite and most quartz and occurs in the late veins as euhedral crystals, euhedral crystals lining vein walls and irregular masses (Richter 1952, p.73). The pyrite contains inclusions of sphalerite and chalcopyrite.

Richter (1952, p.72) reported that spectrographic analysis of the late veins indicate high Ni, Co, Zn, Pb and Cd values. He also reported that the pyrites from the late veins contain higher Co, Ni, Ag, Au and Sn than the massive pyrite (Richter 1952, p.65).

IRON FORMATION - WEATHERING

The cherty layers upon extensive and prolonged weathering decompose to a granular sugary quartz. This quartz may be rust stained due to the weathering of associated sulphides and carbonates.

Weathering of the sulphides creates a porous gossan of orange-brown limonite and sugary textured chert. Prolonged weathering removes most of the original sulphide and the rock may become a chert breccia cemented with limonite-goethite.

Weathering of the siderite and associated sulphides produces a goethite-hematite gossan, which generally penetrates deeply into the iron formation. The chert-bearing facies forms topographically high ridges and weathered chert slumps down over the more easily weathered carbonate-sulphide facies forming a limonite cemented gossan or breccia. This weathering feature can mask or cover up the carbonate facies and prevent its recognition during mapping.

The carbonate facies comes close to surface at the Ruth Iron Range. At this range, the siderite weathers to a dark red brown hematite with associated pyrite grains, crystals and concretions. The hematitic gossan has a distinctive weathering morphology consisting of a knoll or pile of angular hematite-rich fragments generally not exceeding 2 cm in size. This distinctive siderite weathering was also noted on the Rand No.2 Iron Range in Abotossaway Township, north of the map area. These granules of weathered rock may upon breaking display a light buff core of fresh siderite enclosed within a pulverulent hematite rim. The hematite-siderite contact is sharp. The presence of relatively unweathered sulphide within the pulverulent hematite gossan indicates that siderite is more easily weathered than the sulphides.

Deep and prolonged weathering of the siderite and pyrite forms stalagmitic and stalactitic goethite and pulverulent hematite. If some silica is present, the hematite may be hard and display a conchoidal fracture. Chert clasts may occur throughout these weathered deposits. Deep and prolonged weathering at the Helen Iron Range produced the goethite-hematite brown ores extracted immediately after 1900.

Coleman and Willmott (1902, p.171) proposed that weathering of siderite was the origin of the porous and cavernous Helen Iron Range brown ores. Kidder and McCartney (1946, p.23) and Tanton (1948, p.426), however, suggested that the ore originated by the action of hot hydrothermal fluids of magmatic origin on the siderite. Mining has now removed the brown ores and outcrops of these oxidized ores were not available for examination during this project. Mining operations followed the hematite-goethite ores to a depth of approximately 213 m from surface, where fresh siderite and sulphides were encountered (Canadian Mining Journal 1956, p.83; Moore and Armstrong 1946, p.107). Kidder and McCartney (1946, p.23) proposed that cross-faulting gave hydrothermal fluids access to the siderite to form the brown ores but such cross-faulting would also permit access to ground water. The author considers the former brown ores found at the Helen Iron Range to be the product of altered siderite that resulted from fault controlled deep aquifers.

The only other significant hematite deposit in the Wawa area occurs at the Josephine Iron Range immediately north of the map area. This hematite is both hard and pulverulent and occurs in a well-developed chert breccia at the stratigraphic position in the iron formation where siderite would be expected. Siderite is present both east and west of the Josephine hematite deposit and on strike with the hematite-bearing zone. The main difference between the Helen and Josephine deposits is the dominance of goethite at the Helen and dominance of hematite at the Josephine. The Josephine Deposit occurs at the intersection of the Josephine fault and Magpie River fault within the Josephine Iron Range. Drilling in 1941 indicated the hematite was highly brecciated. Cavities in this breccia are

sometimes lined with euhedral hematite crystals up to 15 mm long and with sharply terminated quartz crystals that have a brilliant lustre. The deposit of pyritiferous hematite was tested by drilling to a depth of 500 m before ongoing development (Brown and Morrison 1942, p.9). Brown and Morrison (1942, p.9) attributed the origin of this hematite deposit to the action of hydrothermal fluids of unknown origin on siderite and this model was accepted by other investigators (Moore and Armstrong 1946, p.52). Mining operations in this hematite deposit opened a stope on the 200 m level which caved to surface in 1946 permitting lake sediment above the deposit to enter the mine. The mine was then abandoned but had been developing the hematite deposit to a depth of 333 m at that time.

Mapping by the field party in proximity to the Josephine Mine and along the Josephine Fault and Magpie River Fault has failed to uncover any evidence of hematitization that could be attributed to hydrothermal activity, such as a hematitic hydrothermal alteration halo would be expected. The absence of this feature was also noted by Young (1953, p.119) who consequently rejected a hydrothermal origin for the Josephine hematite deposit. The author is in agreement with Young. The hematite-goethite deposits of the Josephine area likely resulted from ground water action on siderite along breccia zones related to faulting within the iron formation. These breccia zones were created by cross-faults that brecciated and fractured the iron formation but did not greatly offset it. Hematite may be present in very small quantities where the Mildred Lake, Bauldry Lake and Goetz Lake faults cut the Michipicoten Iron Formation but the much greater movement along these faults has likely strung out and dismembered any concentration of siderite breccia that could form the hematitic source rock. The faults permitted groundwater access to the siderite and a aquifer was likely active at one time. The age of hematite formation is unknown. Young (1953, p.120, 121) indicated that both cross-faulting and strike-slip faulting may have exerted some control on the formation of these Fe-oxide deposits. The location of lakes above the Fe-oxide deposits may reflect fault control particularly in the case of the Josephine Hematite Deposit. The present topographic relief is insufficient to permit the development of an aquifer to alter hematite to the depths encountered in former mining operations. Both the Helen and Josephine hematite deposits are likely the result of ancient weathering of siderite and to a lesser extent sulphides along deep, fault controlled aquifers.

IRON FORMATION - ISOTOPES

Within the last few years, isotope studies have been completed on oxygen, carbon and sulphur which provide some constraints on the temperature of formation of the Michipicoten Iron Formation and provide data on possible biological influences in its deposition.

OXYGEN ISOTOPES

Whole rock $\delta^{18}\text{O}$ values on chloritoid-bearing pillowed mafic volcanic rocks above the Helen Iron Formation of + 11.20 ‰ and 10.53 ‰ imply interaction with sea water at $\leq 200^\circ\text{C}$ during rock alteration to compositions favourable to chloritoid formation (LaTour et al. 1980, p.165). Using a quartz-muscovite pair from the Michipicoten Iron Formation, Kerrick and LaTour (1981) obtained $\delta^{18}\text{O}$ values of 6 to 8 ‰ and on a quartz-chlorite pair a $\delta^{18}\text{O}$ values of 10 to 13 ‰. They interpreted the data to indicate that the temperature of formation of the Michipicoten Iron Formation varied from 140 to 220°C .

LeSeelleur (1980, p.47) reported $\delta^{18}\text{O}$ on quartz from the footwall volcanic rocks of the Lucy Iron Range to range from 14.0 ‰ to 17.9 ‰. These values are enriched in $\delta^{18}\text{O}$ relative to primary igneous rocks, suggesting isotopic exchange with ocean water. The $\delta^{18}\text{O}$ shift requires high fluid/rock ratios suggesting that oxygen isotopic values of Archean seawater were essentially the same as present values.

Quartz-muscovite fractions are 6.5 to 7.8 ‰ yielding isotopic temperatures of 150 to 200°C (LeSeelleur 1980, p.47). The isotopic composition of fluid in equilibrium with quartz at these temperatures is 0 ‰ to + 1 ‰; close to present day ocean water. Assuming Archean sea water $\delta^{18}\text{O}$ was buffered to present seawater values of 0 ‰ LeSeelleur (1980, p.53) concluded that the $^{18}\text{O}/^{16}\text{O}$ ratios of the cherts from the siderite at the Lucy Mine represent initial equilibrium with ocean water of -1 to 0 ‰ at temperatures of about 60°C with < 1 ‰ depletion in $\delta^{18}\text{O}$ during diagenesis and metamorphism towards the observed values of approximately 22 ‰. The oxygen isotope data was interpreted to indicate that the Michipicoten Iron Formation is the result of mixing of sea water heated to 200°C during thermal convection through oceanic crust with ambient marine water of 70°C at the ocean floor. Table 2 presents the oxygen isotope values given by LeSeelleur (1980). The positions of the samples used in the isotopic study by LeSeelleur (1980) are plotted on Figure 38.

SULPHUR ISOTOPES

Goodwin et al. (1976, p.870) reported that the mean isotopic abundance of sulphur in 62 samples from 5 cross sections of Michipicoten Iron Formation is $\delta^{34}\text{S}$ of + 0.02 ‰ with a range of 20.6 ‰ (-10.5 to + 10.1 ‰). The highly variable sulphur isotope ratios on both large and small scale within the iron formation are interpreted by Goodwin et al. (1976, p.888) as the result of isotope fractionation during the bacterial reduction of sulphate in an anaerobic environment under variable conditions. They suggest that the banded nature of the

iron formation is the result of intermittent flow of ferrous iron into the basin where iron oxides, carbonates and sulphides were deposited. In the absence of ferrous iron, hydrogen sulphide will build up in deeper anaerobic waters of high biological activity leading to iron sulphide deposition when ferrous iron becomes available (Goodwin et al. 1976, p.888).

Leaching from the metavolcanic rocks is not a likely source for the sulphur since magmatic sulphur isotopes rarely have $\delta^{34}\text{S}$ range greater than 5 ‰ which contrasts sharply with the observed range of 20 ‰ and high variability over short distances (Goodwin et al. 1976, p.888-889).

In a fumarolic sulphur source, the hydrogen sulphide gas will oxidize to sulphur dioxide resulting in some isotope fractionation between H_2S and SO_2 (Goodwin et al. 1976, p.889). At high temperature degassing, the $\delta^{34}\text{S}$ fractionation effect is 3 to 4 ‰ since most of the sulphur is present as H_2S . In a 1:1 hydrogen sulphide-sulphur dioxide mixture $\delta^{34}\text{S}$ variations in the residual H_2S is less than 2 ‰ (Goodwin et al. 1976, p.889). They concluded that if the hydrogen sulphide to sulphur dioxide ratio is less than 1:1 little H_2S remains for ferrous iron precipitation and if it is greater than 1:1 than little isotope fractionation can be expected. As a consequence, volcanic gases would be an unlikely source of large quantities of hydrogen sulphide and their isotopic composition is little different from a magmatic source (Goodwin et al. 1976, p.889).

The sulphur isotope data is interpreted (Goodwin et al. 1976, p.889) to be consistent with bacterial reduction of seawater sulphate to H_2S and this interpretation best explains the highly variable isotopic patterns. Direct volcanic activity is, therefore, not the source of sulphur within the Michipicoten Iron Formation. Volcanic activity was, however, the likely source for the sulphur forming the original sulphate in the Archean seawater.

Additional sulphur isotope studies completed by Thode and Goodwin (1983, p.337) on a cross section of the Helen Iron Range indicate a $\delta^{34}\text{S}$ range of 30.2 ‰, a mean value of 2.5 ‰ and standard deviation of 7.3 ‰. In contrast to the wide ranging, highly variable values found in the oxide and sulphide facies the $\delta^{34}\text{S}$ values in the oxide facies is uniform and close to zero (Thode and Goodwin 1983, p.337). This later study indicated a greater range of sulphur isotope values than previously reported (Goodwin et al. 1976; Thode and Goodwin 1983). The sulphide isotope data is consistent with bacterial reduction of sulphate in a restricted marine basin under changing conditions (Thode and Goodwin 1983, p.352). The ranges in $\delta^{34}\text{S}$ are dependant on batch process enrichment or the flow of fresh seawater into the basin and the banded nature of iron formation is possibly the result of intermittent flow of ferrous iron into the basin. The absence of ferrous iron would permit H_2S build up in anoxic waters with high biological activity until the influx of ferrous iron causes precipitation and H_2S removal (Thode and Goodwin 1983, p.353). The cycle of H_2S

accumulation and removal would reduce the range in $\delta^{34}\text{S}$ values (Thode and Goodwin 1983, p.353).

The lack of evidence for sulphur isotope fractionation in oxide facies suggests a homogenized direct juvenile source (volcanic exhalations) or assimilatory reduction (plant metabolism) of Archean seawater sulfate at a $\delta^{34}\text{S}$ level of 0 (Thode and Goodwin 1983, p.349). The presence of sulphide concretions, sulphide laminae resembling cryptoalgal mattes and branching bulbous masses of sulphide are in the author's opinion more consistent with biological activity than with simple sulphide precipitation.

Goodwin et al. (1976) and Thode and Goodwin (1983) conclude that autotrophic organisms and reducing bacteria played an important role in the formation of Michipicoten Iron Formation. The author favours biological activity to account for the primary structures found in the iron formation and agrees with Goodwin et al. (1976) and Thode and Goodwin (1983) as to the possible importance of biological activity to form the Michipicoten Iron Formation.

CARBON ISOTOPES

Mapping has indicated that carbonaceous material forms a significant component of the Michipicoten Iron Formation and increases in volume as one moves towards the stratigraphic top. Goodwin (1962, p.575) reported the presence of up to 12.8% graphitic carbon in the iron formation. The fact that carbonaceous material forms a major component of the iron formation is amply illustrated by the 20 m thick carbonaceous argillite-pyrite unit exposed by mining operations at the top of the Eleanor Iron Range.

Goodwin et al. (1976, p.870) reported that the $\delta^{13}\text{C}$ values range from -20.4 to -27.7 ‰ with a mean of -24.7 ‰ on carbonaceous chert within the Michipicoten Iron Formation at the Helen and Eleanor Iron Ranges. They also determined that the $\delta^{13}\text{C}$ value on inorganic carbon in massive siderite from the Helen Iron Range was +2.4 ‰ a value similar to Proterozoic marine carbonate. The $\delta^{13}\text{C}$ displacement between siderite and graphitic carbon in the Michipicoten Iron Formation is 27.1 ‰ and it compares with approximately 25 ‰ displacement reported between marine carbonate (chemical precipitate) and organic carbon of Phanerozoic age (Eichmann et al. 1975, p.585).

The magnitude and direction of observed carbon isotope fractionation in the Michipicoten Iron Formation are considered by Goodwin et al. (1976 p.888) to be comparable to other reported fractionation patterns in Precambrian sediments and are interpreted by them to indicate the existence of autotrophic bacteria and support a possible role of photosynthesis in the formation of banded iron formation.

Additional isotopic carbon studies on siderite were completed by Thode and Goodwin (1983). The isotopes fall into the range of Phanerozoic marine carbonates $\delta^{13}\text{C} = -0.1 \pm 2.6$ ‰ cited by Keith and Weber (1964). Thode and Goodwin (1983, p.345, 350) reported a $\delta^{13}\text{C}$ ‰ range of $+0.1$ to -2.9 ‰, a mean of 0.22 ‰ and a standard deviation of 0.8 ‰, on samples of iron formation from the Helen Iron Range excluding samples containing carbonaceous material. Samples from carbonaceous-bearing material ranged from -1.3 to -7.1 ‰ displaying considerable variation with data from other facies of the iron formation indicating the possible mixing of organic and marine carbonate (Thode and Goodwin 1983, p.350).

IRON FORMATION - GEOCHEMISTRY

The values of minor element components within the Michipicoten Iron Formation can be used to assist in postulating an origin and indicate potential for metal commodities.

ORGANIC GEOCHEMISTRY

The presence of carbonaceous matter in the Helen Iron Range prompted Karkhanis et al (1980) to study the organic chemistry of the Helen Iron Range. Karkhanis et al (1980 p.1, 7) reported the presence of two bioforms. These forms are; micron-size filamentous tubular microstructures resembling present day iron bacteria and laminated structures resembling cryptoalgal mats. Karkhanis et al (1980 p.1, 7) identified "n" alkanes, the isoprenoid hydrocarbons pristane and phytane and fatty acids. The presence of pristane and phytane is interpreted by them to indicate high photosynthetic activity. Chromatograms indicate that the prominent fatty acids (methyl esters) are nC14 (monoethenoic acid), nC16 (palmitic) and nC22 (behenic) (Karkhanis et al 1980 p.6). The dominant fatty acid is nC16 and since micro-organisms are known to contain quantities of this acid in their cell walls, its presence may be taken as evidence for a biological source (Karkhanis et al. 1980, p.7). On the basis of organic chemistry and the carbon and sulphur isotope chemistry reported by Goodwin et al. (1976), Karkhanis et al. (1980, p.7) proposed that the deposition of the Michipicoten Iron Formation occurred in the presence of biological reduction of sulfate under anaerobic conditions within a restricted basin at a low concentration of sulfate.

INORGANIC CHEMISTRY

The presence of sulphide facies iron formation as one of the major facies of the Michipicoten Iron Formation has stimulated interest in the minor element content of the iron

formation in hopes of identifying concentrations of elements other than iron which may be of economic interest. The sulphide facies has a strike length of many kilometres. Iron formation units in the Goudreau area have sulphide-rich sections exceeding 30 m in width (Collins and Quirke 1926; Bruce 1940). Considering the volume of sulphide present in the Michipicoten Iron Formation, the presence of either base or precious metals could make the iron formation of economic value even if the tenor of the sulphide ore is significantly lower than most other sulphide deposits.

Within the iron formation, the alumina and silica has been correlated with a residue left from replacement of volcanic rock by the carbonate and sulphide facies of iron formation (Collins and Quirke 1926, p.70). Goodwin (1964, p.717) proposed that most of the silica came from the underlying intermediate to felsic metavolcanic rocks in response to volcanic - fumarolic alteration associate with iron formation deposition. Goodwin (1964) correlated sulphur with the presence of sulphide, silica with the presence of chert and alumina with the presence of tuffaceous debris, both replaced and unreplaced, that occurs in the iron formation. Both Goodwin (1964, p.692) and the author consider the volcanic debris, both replaced and unreplaced, that occurs in the iron formation to have been washed into, or blown into the Archean Sea and to have settled into the depositing iron formation. The carbonate and silica contents are reported to display an antipathetic relationship (Goodwin 1964, p.709).

Collins and Quirke (1926, p.62, 63) reported Cu values varying from 0.03 to 0.20% at the Lucy Iron Range, Ni values varying from 0.02 to 1.10% (averaging 0.38%) at the "C" deposit Goudreau (outside the map area) and an average Ni value of 0.52% for 6 drill holes on the "A" deposit Goudreau (outside the map area). They reported an average value of 1.08% Zn in drill core from the "A" deposit Goudreau (outside the map area) and a value of 1.48% Zn from the Ruth Iron Range. Anomalous zinc values are reported to occur in the Big Lake Iron Range (outside the map area).

Richter (1952, p.61) reported that the Michipicoten Iron Formation contains high Co and Ni values, however, the reported values are nearly all less than 0.01%. The higher cobalt and nickel values occur in pyrite with the highest values occurring in the pyrite found in the later veins rather than from within pyrite found within the iron formation (Richter 1952, p.65). Richter (1952, p.63, 64) compared the Cu, Pb, Zn and Ag content in Michipicoten Iron Formation siderite with values found in carbonate sediments (various sedimentary siderites) and found higher values in the siderite. He interpreted the data to indicate that the siderite was of hydrothermal origin rather than sedimentary.

Goodwin et al. (1985) found the Michipicoten Iron Formation to be low in base and precious metal content which they relate to a relatively low temperature of formation.

In an attempt to better understand minor element distribution in the Michipicoten Iron Formation systematic sampling of fresh iron formation was completed (Figure 38). The ideal way of undertaking this study would be the analysis of 0.3 m sections of drill core from a hole that cuts the iron formation from the upper to lower contact and penetrates good examples of all facies of iron formation, rather than the grab sampling techniques used by the author. Mining operations on the Lucy and Eleanor iron ranges have exposed the Michipicoten Iron Formation from which fresh grab samples were obtained. The lower stratigraphy is well exposed at the Lucy and the upper stratigraphy is well exposed at the Eleanor Iron Range. Since no mining operation has exposed a complete section, a composite section from the two iron ranges was made. It is unknown whether sampling of the lower stratigraphy at the Lucy Iron Range overlaps with the upper stratigraphy sampled at the Eleanor Iron Range. A gap in the section is possible. Sampling of the section was at 1.3 m (5.0 feet) intervals and the data was plotted on graphs to show element concentration versus height in the stratigraphic section. A description of the samples is given in Table 3 and the chemical data is given in Table 4.

ARSENIC

Arsenic values in the iron formation are erratic and high. The high values reflect the presence of arsenopyrite in the iron formation and appear characteristic of the Michipicoten Iron Formation. Arsenic values in excess of several 100 ppm are common within the metavolcanic stratigraphy and the metavolcanic rocks are a likely source for the arsenic as well as the iron and silica that make up the Michipicoten Iron Formation. Goodwin (1961, p.26) reported anomalous As in the footwall rocks of the Helen Iron Range.

GOLD

Gold values in the iron formation are erratic and concentrated within the carbonate and sulphide facies. The gold values are elevated with respect to the overlying intermediate to mafic metavolcanic rocks but remain far below values of potential economic interest (Table 5).

BORON

Boron appears to be concentrated towards the base of the iron formation and relatively constant in concentration throughout most of the remaining section. Goodwin

(1962, p.26) reported anomalous boron in the footwall rocks at the Helen Mine. He interprets the presence of boron along with what he interpreted as anomalous arsenic values as supporting hot spring model for the formation of the iron formation. Boron content of the overlying intermediate to mafic metavolcanic rocks is erratic but comparable to the upper part of the iron formation. The lower part of the iron formation appears strongly enriched in boron with respect to the upper part of the iron formation and underlying tuffs.

Tourmaline-bearing intermediate to mafic metavolcanic rocks are common in the southeast corner of Musquash Township (outside the map area), north of the Lucy Iron Range. This tourmaline commonly replaces pillow selvages and occupies crosscutting fractures within the mafic metavolcanic rocks. The tourmaline appears to be the result of hydrothermal alteration (hot spring?) but there is no association of iron formation with the tourmaline alteration. While anomalous boron may indicate hydrothermal activity it need not be associated with iron formation deposition.

BARIUM

The barium content of the iron formation is relatively constant. The barium content of the iron formation is less than that of the footwall rocks implying limited barium mobility assuming that the elements comprising the iron formation came from the footwall metavolcanic rocks.

BISMUTH

Bismuth is enriched in the base of the iron formation within the carbonate and sulphide facies. The bismuth concentration of the upper part of the iron formation is comparable with the footwall tuffs.

CERIUM

The iron formation contains minor cerium within the carbonate facies at the base, however the cerium content of the iron formation appears to be much less than in the footwall tuffs. The cerium distribution implies limited mobility assuming the elements making up the iron formation had their source in the footwall metavolcanic rocks.

COBALT

With the exception of several anomalous samples the cobalt content of the iron formation is not much different from that of the footwall volcanic rocks. This finding contradicts the conclusion of Richter (1952, p.61) that the iron formation is enriched in cobalt and nickel. The author has observed what appears to be erythrite staining on iron formation at the entrance to a decline on the Ego Mines Limited Property Abotossaway Township (outside the map area). Assay data are not available to confirm the presence of cobalt. This iron formation is a chert-magnetite unit and may not be genetically similar to the Michipicoten-type Iron Formation characterized by siderite and sulphide facies.

CHROMIUM

Chromium is generally low with respect to the chromium content of the footwall rocks. This probably reflects a lack of mobility during the alteration process coeval with iron formation deposition.

COPPER

Copper values are highly erratic but may be slightly higher on average in the iron formation than in the footwall tuffs. In general, the copper is present in sulphide-rich specimens and a copper anomaly appears to be present in the graphitic chert at the top of the exposed section in the Lucy pit. In general, the copper content is far below that which could remotely be considered encouraging for additional exploration. The data resulting from this investigation indicate anomalous copper values can be obtained within the Lucy Iron Range, however most samples collected by the field party return relatively low values. Jalore Mining Company Limited reported high copper values to be present in the East Brooks Iron Range but did not state quantitative values.

GALLIUM

Gallium within the iron formation generally occurs in concentrations below that found in the footwall tuffs. A sharp gallium anomaly occurs between 21 and 24 m above the base and at the very top directly below the intermediate to mafic metavolcanic rocks of cycle two.

LITHIUM

Lithium is depleted in the iron formation relative to the footwall tuffs. A sharp peak in Lithium concentration occurs at 21 to 24 m above the base but this peak is still below values found in the footwall tuffs. The absence of lithium in the iron formation relative to the footwall implies that the lithium was not mobile during alteration and deposition at the iron formation. It could also mean lithium remained in the Archean seawater and was never precipitated.

NIOBIUM

Minor niobium is present in the carbonate and sulphide facies of iron formation, however, its concentration is far below that found in the footwall tuff. Niobium appears immobile to the alteration processes accompanying iron formation deposition.

NICKEL

Nickel is slightly anomalous in several areas of the iron formation relative to the footwall tuffs. Nickel is depleted in the carbonate facies. The anomalously high values are probably associated with the presence of sulphide. The nickel values of the upper cherty and graphitic part of the iron formation are comparable with the footwall tuffs. The Lucy Iron Range data (this study) does not indicate such high nickel contents.

MANGANESE

The manganese content of the carbonate and sulphide phases of the iron formation is high. The manganese occurs with the carbonate and values of several percent are standard. The manganese content is one of the reasons that the Michipicoten iron ores are desired for steel making. The manganese is likely a primary component of the iron formation.

LEAD

Lead values are erratic and often below values found in the footwall tuffs. Lead peaks occur in both the carbonate facies and sulphide facies. There is a trend towards increasing lead concentrations in the upper part of the iron formation.

ANTIMONY

Antimony is erratic in concentration but sharp increases in concentration occur at the base within the carbonate facies. A sharp increase in antimony occurs between 21 and 24 m above the base and the upper chert and graphitic part of the iron formation is also consistently above footwall values.

SCANDIUM

Detectable scandium occurs at the bottom of the iron formation within the carbonate and sulphide facies iron formation. Scandium is below the detectable limit for the upper part of the iron formation. Relative to the footwall tuffs, the iron formation is depleted in scandium. If most of the elements making up the iron formation came from the underlying tuffs via alteration, scandium was relatively immobile during the alteration and iron formation depositional process.

SELENIUM

Selenium is below detection limits for most at the footwall tuff. Selenium is concentrated in the carbonate facies at the lower contact, at 21 to 24 m above the base and displays erratic but increasing concentration in the upper cherty and graphitic part of the iron formation. Selenium appears concentrated in the iron formation relative to the footwall tuffs.

TIN

Tin concentration is erratic and with the exception of one sample, the lower part of the Lucy Iron Range contains tin values similar to those found in the footwall tuffs. The upper part of the Eleanor Iron Range is anomalous in tin relative to the lower part of the iron formation exposed at the Lucy Iron Range. The tin values are generally low.

STRONTIUM

The strontium content of the iron formation is generally much lower than that found in the footwall tuffs. A peak in strontium content occurs between 21 and 24 m above the base but this peak in concentration remains below values found within the footwall tuffs. A

rapid rise in strontium content occurs within the chert and graphite section of the upper part of the iron formation. The increase in strontium in the upper part of the iron formation may reflect an increase in the detrital component within the iron formation.

VANADIUM

Vanadium occurs within the iron formation at concentrations, below that found in the footwall tuffs. An increase in the concentration of vanadium occurs at the top of the iron formation but values remain below those found within the footwall tuffs. Vanadium appears to have been relatively immobile during the alteration and iron formation deposition process.

YTTRIUM

Yttrium values are erratic within the lower carbonate and sulphide facies iron formation and are similar to those found within the footwall tuffs. Detectable Yttrium values are generally absent through the cherty section but show a pronounced increase in the graphite-rich section below cycle two metavolcanic rocks.

ZINC

Zinc throughout the lower part of the carbonate and sulphide facies iron formation is similar to values found within the footwall tuffs. Zinc is highly erratic and anomalous in the upper graphite-rich part of the iron formation. Anomalous zinc is reported to be present within the sulphide facies of the Big Lake Iron Range, Corbiere Township. Zinc values found within sulphide facies iron formation at the Lucy Iron Range do not appear particularly anomalous in zinc relative to the footwall tuffs. From this study, high zinc values, if present, are more likely to occur within the upper chert and graphite facies.

ZIRCONIUM

Zirconium is present in quantities far below the values found within the footwall tuffs. Two sharp peaks occur in zirconium concentrations. One peak occurs at 21 to 24 m above the base and the second occurs at the upper contact with the overlying metavolcanic rocks of cycle two. The zirconium anomaly at the top may be due to the presence of traces of detrital zircon concentrated at the surface of the iron formation by winnowing currents before it was capped by the overlying metavolcanic flow.

MINOR ELEMENT CHEMISTRY - SUMMARY

The minor elements Ag, Hg, Cd, Be, Mo and U were analyzed for their presence but they generally occurred in concentrations below the limits of detection. The elements Au, B, Cu, Cr, Ni, Sb and Se are moderately to strongly enriched at the base of the iron formation and Pb and Bi may have undergone a minor concentration at the base. The base of the iron formation at the Lucy Iron Range is dominantly carbonate facies with subordinate arsenopyrite and iron sulphide.

At the top of the iron formation, in the graphitic, cherty argillite, Ba, Se, Sr, Zn and Zr are concentrated. Lead, Sb, Sc, Sn, V and Y also display minor enrichment at the top.

At the stratigraphic position of 21 to 24 m above the base, Au, Ca, Cu, Ga, L, Sb, Se, Zn, Zr are moderately to strongly concentrated. Lead, Sb, Sc, Sn, V and Y also display weak to moderate enrichment at this position. At 21 to 24 m, a sharp break occurs in the internal structure of the iron formation with a pronounced parting parallel to the bedding plane surface occurs at this position and a fine-grained siliceous ash bed. The transition from massive siderite-pyrite to thin bedded to laminated siderite, pyrite and chert is abrupt across this bedding plane and an internal unconformity may occur in the iron formation at this position. A hiatus in iron formation deposition and possibly some erosion of the iron formation and winnowing by currents and concentration of detrital components may have taken place. At this position, minor quantities of base metals may have been precipitated or concentrated by winnowing of base metal-rich detritus to account for the observed increase in base metal concentrations. The increase in zirconium at this position could be due to traces of zircon being concentrated by current winnowing action as proposed by the author for the zirconium concentrated at the upper surface of the iron formation. The author is unaware of possible unconformities within other iron ranges of the Wawa area. Unconformities would be difficult to recognize in drill core, underground workings, or in weathered outcrops.

With respect to the footwall tuffs, Ce, Cr, Li, Nb, Sc, V and Y in the iron formation are moderately to strongly depleted. Gallium may be weakly depleted with respect to the footwall. A number of major elements that compose the iron formation; that is, Si, Fe, Mn and As, likely result from alteration of and transport from the footwall metavolcanic rocks by deeply circulating hydrothermal fluids, those elements that are depleted with respect to the footwall metavolcanic rocks may be considered relatively immobile. If they were not immobile they were not precipitated and remained within the Archean sea. Metavolcanic detritus is common throughout the iron formation and undoubtedly contributed to the observed minor element concentrations. If it was feasibly possible to physically removed all

this detritus from the iron formation samples before analysis, the apparent immobility of some elements, such as Ce and Nb may be very strong. The relative immobility of several elements, may offer some potential for future geochemical studies of the iron formation and associated metavolcanic rocks.

MICHIPICOTEN-TYPE IRON FORMATION - ENVIRONMENT OF DEPOSITION

The configuration of the basin of deposition for the iron formation has been interpreted by Goodwin and Shklanka (1967, p.792) from a west to east direction as one representing an increasing depth, which corresponds to deposition of oxide to sulphide facies iron formation. Goodwin and Shklanka (1967, p.792); Goodwin 1961, 1962, 1973) based this model on the following observations:

1. A transition of oxide to sulphide facies iron formation from west to east. This is a function of the change from shallow water in the west (oxidizing environment) to deep water in the east (reducing environment). (Note: Mapping by the author has not established a deep water environment as one moves east).
2. Conglomerate-bearing metasedimentary rocks in the west and shale metasedimentary rocks in the east are associated with the iron formation. This suggests a source area to the west and on east-sloping shelf.
3. A transition of oxide facies to carbonate iron formation at a position where conglomerate is transitional to fine-grained clastic rock.
4. The chert facies is thicker in the western part of the area and thin to absent in the east (Goudreau).
5. The sulphide member is thickest in the east and thin to rudimentary in the west.
6. The carbonate member is thickest in the central part of the Helen and Magpie Mine Iron Ranges and thin in the eastern part (Goudreau). The carbonate member is increasingly calcareous to the east.

Goodwin (1962, p.579) considered the Michipicoten Iron Formation to have been deposited on broad shield-like pyroclastic domes of considerable relief with thickening and thinning of the iron formation a function of original topography and not later tectonism. He also considered the iron formation to be a deep water deposit based on pillow structures in the nearby metavolcanic rocks and the presence of graded bedding and laminations in associated metasedimentary rocks (Goodwin 1962, p.579). He also reported the absence of ripple marks, channeling and cross-bedding to support the deep water model.

The association of iron formation in the western part of the Wawa supracrustal belt with metasedimentary rocks and with volcanic rocks in the east has not been supported by the present mapping. The Dore metasedimentary rocks on which this model is based do not correlate with nor are they directly associated with the Michipicoten Iron Formation. The Dore metasedimentary rocks interfinger with the intermediate to felsic metavolcanic rocks of the Magpie River volcanic centre sited north of the Magpie River dated by Turek et al. (1982, p.1621) by U-Pb techniques as 2696 ± 2 Ma. The intermediate to felsic metavolcanic rocks directly below the iron formation were dated by U-Pb techniques as being 2749 ± 2 Ma (Turek et al. 1982, p.1621). The Dore metasedimentary rocks are thus approximately 50 million years younger than the iron formation. At the Lucy Iron Range, which is the best exposed and least deformed of the iron ranges, approximately 1000 m of massive and pillowed intermediate to mafic metavolcanic rocks separate the clastic metasedimentary rocks from the stratigraphically lower iron formation.

Immediately below the Helen Iron Range for a distance of 30 to 40 m the metavolcanic rocks have been reworked and display excellent graded bedding (Plate 32). Cross-bedding is also present in this section indicating transport from west to east. This local reworking was observed only at the Helen Iron Range. There is little evidence of metasedimentary rocks above or below the iron formation and therefore the Michipicoten Iron Formation is purely of volcanic association. Sedimentation occurred intermittently during iron formation deposition and consists of thin wacke beds and carbonaceous, siliceous argillite. This type of sedimentation does not significantly vary throughout the presently mapped strike length of the iron ranges.

At the top of the intermediate to mafic, massive to pillowed metavolcanic section of the lower cycle one metavolcanic rocks, amygdulites in the pillow margins approach and sometimes exceed 1 cm in maximum dimension. On graphs prepared by Moore (1965, p.43) of amygdulite diameter versus water depth (pressure), such large amygdulite size indicates low pressure or relatively shallow water conditions. Immediately below the Lucy Iron Range a distinctive breccia consists of angular to subrounded clasts with oval to elongate pipe-like amygdulites. The amygdulites compose up to 50% of some fragments and the elongated ones may exceed 2 cm in length. The oval amygdulites may exceed 1 cm in long dimension. This unit may be as much as 20 m in width and extends along the base of the iron range for most of its strike length even though its presence has not been observed at other iron ranges. The presence of chlorite in combination with amygdulite size and shape is more consistent with an original mafic composition. The field interpretation that this breccia unit was originally mafic in composition even though alteration has created a rock which weathers an orange brown colour, which could be hastily classified as felsic, was by D. Hunter (Algoma

Ore Properties Limited, personal communication, 1980). Hunter mapped in detail the area around the Lucy Iron Range. The possibility that the immediate footwall rocks at the Lucy Iron Range were mafic and not felsic as at the other iron ranges was also suggested by Young (1953, p.96) who found the titanium content of the underlying tuffs to be too high for typical felsic rocks. Eden (1980, p.24) has also classified the footwall tuffs immediately below the iron formation as mafic.

Since this footwall breccia was likely originally mafic in composition makes possible a comparison of amygdule size and volume with graphs prepared by Moore (1965, p.43) which indicate deposition under very low pressure implying relatively shallow water.

Examination of the intermediate to mafic flows of cycle two metavolcanic rocks above the Helen and Lucy iron ranges indicates the presence of amygdules which sometimes exceed 2 cm in long dimension in the margins of pillows. Nebel (1982, p.60) proposed that the Helen Iron Range was deposited under shallow water conditions on the basis of amygdule size.

Above cycle two metavolcanic rocks, at the Lucy Iron Range, the Dore metasedimentary rocks display trough cross bedding, ripple marks, desiccation cracks and conglomerates of possible fluvial origin in the upper part of their stratigraphic section. The western extension of these metasedimentary rocks west of the Mildred Lake Fault and above the Johnson Iron Range, have been interpreted to represent from stratigraphic bottom to top; alluvial fan deposits, interchannel deposits on a submarine fan, overbank and in-channel deposits and braided stream deposits (Neale 1980). Thomas (1984) has made a similar environmental interpretation for the metasedimentary rocks above the Lucy Iron Range.

The Wawa supracrustal rocks are likely tilted to the west due to the influence of the Kapuskasing Structural Zone (Percival and Card 1983, p.325; Percival and Krogh 1983, p.830). This tilting presents an oblique cross section of the belt such that ever deeper levels of exposure within the Wawa supracrustal rocks are exposed as one moves eastward. Primary structures within the metavolcanic rocks or metasedimentary rocks within the stratigraphic section above and below the iron formation do not support ever increasing water depth (pressure) as one moves west to east as proposed by Goodwin and Shklanka (1967 p.792). The basin into which the volcanic rocks and sedimentary rocks were deposited and concurrently subsided and was not likely ever of a abyssal nature. Limited paleocurrent directions indicate west to east sediment transport implying deepening of the basin towards the east.

The excellent grain gradation of wacke layers within the cherty facies of iron formation imply that water depth was below storm wave base at the time of iron formation

deposition. The interformational chert breccias, as discussed above, are considered to be the product of sediment disruption in a tectonically unstable volcanic environment.

In 1979, D. Hunter (Algoma Ore Properties, personal communication, 1980) examined siliceous-siderite cemented breccias in the footwall rocks beneath the Lucy Iron Range. The breccias occur as ramifying dikes and breccia-fined fractures that crosscut and enclose blocks of footwall tuff (Plate 33). The dark brown weathering siderite makes the crosscutting breccias easily recognizable in the field. The breccias occur only within 30 to 50 m of the base of the iron formation and do not cut it. Secondary schistosity cut the breccias indicating a predeformational origin which combined with their spatial distribution imply a origin related to formation of the iron formation. Hunter interpreted the breccias to be hydroexplosion or phreatic explosion breccias which developed as a result of sealing of the underlying permeable tuffs by mineral deposition resulting in explosive steam release as the hydrothermal fluids reached a low-pressure near surface environment and found the passages blocked. The blasting of such hydrothermal vents would likely result in highly variable volumes of fluid flow (tortuosity) within the porous tuffs forming the underlying aquifer. The author agrees with Hunter's interpretation.

The author encountered similar breccias at the Helen, Ruth and Josephine Iron Ranges in exactly the same stratigraphic position as at the Lucy Iron Range (Plate 34). The interpretation that this breccia is the result of steam explosion places constraints on pressure or water depth. Boiling point curves on a 5% brine solution developed by Finlow-Bates and Large (1978, p.31) suggested boiling at the seafloor can occur at maximum water depths of 400 m and a temperature of 250°C. If the oxygen isotope data is correct and the iron formation was deposited more or less at 200°C than the water depth may approach depths as shallow as 200 m (Finlow-Bates and Large 1978, p.31). Nebel (1982, p.55, 59) described these breccias at the Helen Iron Range and also referred to them as hydroexplosion breccias.

In summation, the Michipicoten Iron Formation represents a period of chemical and clastic sedimentation at a hiatus between cycle one and cycle two volcanism. The iron formation was deposited in relatively shallow water, below storm wave-base, in an Archean basin of restricted size and shape. There is little evidence of significant change in water depth at the time of iron formation deposition along the presently mapped strike length even though paleocurrent directions in overlying sedimentary rocks indicate a west to east direction of sediment transport and regional structural analysis indicates that the eastern end of the supracrustal belt should expose deeper levels of the Archean basin.

MICHIPICOTEN-TYPE IRON FORMATION - ORIGIN

There is extensive literature on the origin of Michipicoten Iron Formation and only a brief synopsis is presented here. The author is in general agreement with the conclusions of Young (1951, 1953).

Coleman and Willmott (1902) considered the Michipicoten Iron Formation to be a sedimentary rock and proposed that biological activity may have played a role in its formation. These ideas were subsequently rejected and for the next 50 years a replacement origin was promoted. Arguments for replacement were centred on whether replacement was pre- or post-folding rather than on whether replacement was indeed viable. Young (1953) proposed a sedimentary hypothesis for the iron formation and recognized the possibility of biological activity in its formation. Subsequent to this work, numerous papers by several authors dealing with field relations, chemistry and isotope geology have been published supporting the essence of Young's (1953) interpretation. Young's (1953) work begins the modern concepts on the origin of the Michipicoten Iron Formation.

IRON FORMATION - CHRONOLOGICAL HISTORICAL REVIEW

Coleman and Willmott (1902) recognized the association of Michipicoten Iron Formation with volcanic rocks and proposed that it resulted from chemical precipitation during periods of diminished volcanic activity. The waters precipitating the iron formation were charged with lime, iron and silica and they recognized the possibility that biological activity played an active role in its formation (Coleman and Willmott 1902, p.170, 183).

Bell (1905) investigated all known iron formations in the Michipicoten region. Coleman (1906a) provided a summary of his ideas on the Helen iron Range in which he proposed that the oxide iron ores being mined at that time formed from siderite in a synclinal structure in response to reaction with hot fluids.

Collins and Quirke (1926, p.71, 73) completed an extensive study of Michipicoten Iron Formation and interpreted the siderite and sulphide facies to have resulted from complete replacement of underlying felsic tuffs by hot water solutions of igneous origin that were related to volcanism. Collins and Quirke (1926 p.71) considered the carbonate and pyrite members to be gradational into the underlying volcanic stratigraphy which is at variance with observations made during the present survey. The silica member was considered to be a chemical deposit and its constant association with siderite and sulphide suggested to them that all three units (ie. chert, sulphide, carbonate) formed at the same time by the same chemical agent (Collins and Quirke 1926 p.73).

A replacement origin for the sulphide and carbonate facies is based on the presence of volcanic clasts in the iron formation which have undergone replacement. The amount of volcanic material decreases upward and the order of replacement is feldspar first, quartz second and mafic minerals last (Collins and Quirke 1926, p.68).

It was proposed by them that the silica was deposited on the surface of a Keewatin volcanic complex and that the pyrite and carbonate represent replacement of the volcanic complex adjacent to the surface and below the silica layer (Collins and Quirke 1926, p.71). Collins and Quirke (1926 p.74, 77) considered the silica-depositing and sulphide-carbonate replacing agent to be a warm to hot iron bicarbonate- and hydrogen sulphide-bearing magmatic water solution possibly concentrated in carbonate and sulphide ions. This hot solution was acidic in nature and leached silica from the underlying volcanic rocks, transported the silica to surface and then deposited the silica on the exposed land surface (Collins and Quirke 1926, p.74, 78). The silica was deposited under surface oxidizing conditions and the pyrite and siderite under reducing conditions beneath the surface (Collins and Quirke 1926, p.75). Collins and Quirke (1926, p.75, 76) consider the iron formation to have formed at the loci of hot spring activity, that ranged from a few yards to 7 or 8 miles in length.

The author and Goodwin (1962, p.574) consider that most of the iron ranges in the Michipicoten supracrustal rocks form two major regional stratigraphic units that have been segmented by faulting. Within the Wawa supracrustal rocks, the Michipicoten Iron Formation is the older of these two major regional iron formations. Collins and Quirke (1926, p.74), however, considered the various ranges to represent various isolated bodies more likely formed on an exposed land surface rather than a single segmented iron formation horizon. Collins and Quirke (1926, p.75) interpreted the deposition of the iron formation on an exposed land surface by interpreting the irregular laminations of the chert, the brecciated zones in the chert and conversion of siderite to iron oxide as being due to flowing water and exposure to the air. The author does not consider the irregular discontinuous pinching and swelling of chert beds as indicating subaerial formation and has offered an alternative subaqueous interpretation for the breccias. The presence of mixed siderite and magnetite are not considered by the author to indicate subaerial conditions but rather rapidly changing physical conditions at the time of deposition. Magnetite may be of detrital origin or the result of diagenetic processes after deposition. The proposal of Collins and Quirke (1926, p.78) that the silica source is likely the underlying volcanic rocks is consistent with the view of Goodwin (1962, p.579) and the author.

Grout (1926 p.816) rejected the proposed model that all three iron formation facies (ie. chert, sulphide and carbonate) were the product of the same chemical agent. Grout

(1926, p.816) proposed that the depositing waters were hot and concentrated and that the silica was leached from the tuffs by flowing water. The metavolcanic rocks were the proposed heat source.

The replacement of the tuff, was by CO_2 - and H_2S -bearing waters of magmatic origin which upon reaching the impervious silica cap became impounded permitting complete replacement of the tuffs. The presence of pyrrhotite (Collins and Quirke (1926 p.70) was interpreted by Grout (1926 p.816) to indicate a deep-seated (high pressure and temperature) replacement. Grout (1926, p.816) proposed a three-stage model; chert deposition on a land surface, deep burial and replacement of the tuffs beneath the impervious cap by fluids of magmatic origin.

Moore (1931 p.43, 45) is in general agreement with the proposed origin presented by Collins and Quirke (1926) with the modification that replacement occurred after deep burial as proposed by Grout (1926). Moore (1931, p.45) proposed that the chert is analogous to siliceous sinter and that the siderite replacing the tuffs was of Keewatin age. The pyrite was formed later, replaces the siderite and has its source in felsic Algonian intrusions present in the region (Moore 1931 p.45).

Bruce (1940, p.16) accepted the replacement origin for the siderite and pyrite. Bruce (1940, p.16) considered the presence of lenses of schistose volcanic rock within the siderite and pyrite and the lense-like nature of the siderite and pyrite bodies to be consistent with replacement origin. He questioned Collins and Quirke (1926) suggestion that all three facies (ie. chert, pyrite and siderite) were formed at the same time as a result of a near surface pressure gradient. Bruce (1940, p.16) proposed that the replacement took place after folding and that fractures and shearing along the flanks of the chert unit permitted access to the replacing fluids.

Hawley (1942) examined in detail the Rand No.2 Iron Range, Abotossaway Township and accepted the replacement origin for the iron formation. He cited the presence of pyritized schistose metavolcanic rocks in the iron formation and lack of deformation within the iron formation in contrast to deformation within the enclosing metavolcanic rocks, as evidence in support of a replacement origin for the pyrite, siderite and some of the chert (Hawley 1942, p.84, 85). Hawley did not extend this idea of a replacement origin for the chert at the Rand No.2 Iron Range throughout the Wawa-Goudreau area. Hawley (1942, p.85) interpreted the banding in the siderite, pyrite and some of the chert to be a relict feature inherited from the metavolcanic rocks. The presence of the iron formation at the mafic-felsic metavolcanic contact was interpreted by him to be a structural feature; that is, this contact was a zone of weakness that permitted access to the replacing and mineralizing fluids (Hawley 1942, p.85).

Kidder and McCartney (1946, p.14) considered the siderite to be of replacement origin of pre-existing tuffs by iron-bearing hydrothermal fluids of magmatic origin. They interpreted the replacement to be post-folding. The interpretation of some narrow carbonate units in rocks outside the orebody as siderite was considered as evidence for a replacement origin (Kidder and McCartney 1946, p.18). In addition, they cited gradational siderite and chert contacts, siderite crosscutting the chert, siderite replacement of chert and tuff, tuffaceous fragments in the siderite and quartz eye zones in the siderite resembling quartz eye tuffs south of the ore body in support of the replacement model (Kidder and McCartney 1946, p.18-20). Kidder and McCartney (1946, P. 211) reported that pyrite and pyrrhotite replace siderite and magnetite replaces siderite marginal to diabase dikes. Replacement of the siderite by pyrite may be so complete as to form massive bodies. Kidder and McCartney (1946, p.24) proposed an intimate association of siderite and metadiorite and suggest that the siderite is derived by magmatic processes related to the emplacement of the metadiorite. They admit that the most difficult observation to be explained by the replacement model is the presence of narrow bands of siderite within the banded chert.

Moore and Armstrong (1946, p.5, 68) examined several iron ranges and added little to the model presented by Moore (1931). They believed that siderite and pyrite replacement of the metavolcanic rocks occurred much later than silica deposition and that it was structurally controlled (Moore and Armstrong 1946, p.5, 68). Deposition was post-folding and post-brecciation of the chert. Moore and Armstrong (1946, p.5) interpreted the chert laminae to have resulted from an influx of iron and silica after rainstorms with iron-rich layers deposited first followed by silica.

Tanton (1948, p.426) interpreted the Michipicoten Iron Formation to be a replacement deposit resulting from the influx of hot magmatic fluids. In addition to forming the siderite and pyrite by replacement, he also suggested that the near-surface hematite ores at the Helen Iron Range were the result of hydrothermal fluids, possibly related to diabase dike emplacement, acting on the early formed siderite (Tanton 1948, p.426). Tanton (1948, p.424) attributed irregular masses of greenstone within the siderite, interbedded chlorite schists and the banded structure of the iron formation to be relicts left over from replacement of the tuffs. He considered the metadiorite intrusions and chloritoid alteration to be younger than the banded iron formation but older than the siderite (Tanton 1948, p.424).

Young (1951) completed a detailed study of the Lucy Iron Range which was followed by a regional study of the iron formation. Observations and interpretation made by Young (1951) at the Lucy Iron Range are as follows:

A. Lower contact of Lucy Iron Formation displays a sharp siderite-tuff contact. Siderite nodules at base of contact are likely sheared into tuff during folding. Gradational contact not present (p.40).

B. There is clear evidence of replacement of rock-forming silicates in the metavolcanic rocks below the iron formation, however this is principally by ankerite not siderite. Ankerite veinlets cut the siderite and are clearly younger (p.39).

C. The textures within the siderite and its relationship to other members of the iron formation are consistent with sedimentary origin (p.39).

D. Replacement ankerite forms euhedral porphyroblastic outlines while siderite forms an anhedral granoblastic mosaic typical of limestone (p.40).

E. Fine interbanding of pyrite and siderite resembles graded bedding implying sedimentary origin (p.40-41). (Note: This feature was not confirmed during the present survey).

F. Mafic iron silicates and other rock-forming silicates typical of mafic rocks customarily are less resistant to alteration and replacement than quartz and plagioclase of felsic rocks. Therefore, why would the sulphide and carbonate iron formation replace felsic in preference to mafic metavolcanic rocks (p.40).

G. If the siderite formed by replacement, it should display a relationship to favourable beds not just silica (p.42).

H. Carbonatization is pervasive throughout the area and displays no evidence of influence by the silica bands (p.42). Therefore, why would siderite replacement be so influenced.

I. Primary carbonate occurs stratigraphically below the iron ranges; therefore, conditions for carbonate deposition existed before the iron formation was deposited (p.43).

J. At most sites within the Lucy Iron Range the silica member exceeds the pyrite plus siderite units. If replacement occurred a variation in this distribution would be expected (p.43).

As a result of a much broader regional study of the iron formation Young (1953) made the additional observations.

A. The presence of intraformational breccia consisting of randomly oriented laminated chert clasts in a sideritic groundmass is a primary depositional feature (p.64).

B. The presence of interformational breccia of banded iron formation within the overlying metavolcanic rocks suggests that the iron and silica are depositional features

consistent with a process of sedimentation (p.64). (Note: These intraformational breccias were not encountered in the present survey).

C. The presence of interbedded replaced tuffs within the iron formation would be expected in a volcanic environment and does not mean the complete unit is of replacement origin (p.63).

D. The extensive replacement of the iron silicate minerals in the metavolcanic rocks by carbonate would free the iron thus implying that the metavolcanic rocks are a source for the iron.

E. Carbonate alteration (ankerite) of the metavolcanic rocks is post iron formation and may have taken place during folding.

F. Carbonate alteration (ankerite) is present in mafic intrusions cutting the iron formation.

G. Siderite in ore bodies is the same age as in the silica layers and is not post-silica or post-folding.

H. High titanium values in immediate footwall tuffs to the iron formation indicate a mafic and not a felsic parentage (restricted to the Lucy Iron Range).

I. In the chert breccias, cross cutting siderite bands would be expected in a sedimentary environment as the chert layers crack and fracture and become filled with siderite. The siderite does not display replacement textures next to the chert indicating both are from the same source.

J. A lower silica unit does exist in some iron ranges within or below the siderite (Goodwin 1964, p.577). If chert ponded siderite-bearing fluids than these lower cherts would not be bypassed. (These lower cherts may not be in their original position but represent tectonic repetition of the stratigraphy).

K. The carbonate within the siderite, pyrite and chert facies of iron formation is identical in composition and therefore likely of the same origin. The carbonate found in the associated metavolcanic rocks is different in composition from that found in the iron formation.

L. The large areal extent of the Michipicoten Iron Formation and consistent stratigraphic position suggests a sedimentary origin (p.101).

M. Microscopic texture of siderite is comparable to fine-grained recrystallized limestone and is similar throughout the region (p.103).

N. Cobalt and nickel ratios are consistent with a sedimentary origin (p.103).

O. Bedding in underlying tuffs is consistent with sedimentary origin (p.103).

P. Pyrite is concentrated in silica-rich layers and not carbonate (p.108). (Note: At the Helen Iron Range large quantities of pyrite are not commonly associated with siliceous siderite-magnetite banded iron formation).

Q. Oolites and granules considered to be of primary origin are present in the Michipicoten Iron Formation (p.111).

R. The presence of carbonaceous material in oolitic or granular structures strongly indicate an organic origin (p.114).

As a result of the detailed observations, Young (1951, 1953) concluded that the Michipicoten Iron Formation is the product of chemical sedimentation. He was the first investigator since Coleman and Willmott (1902) to recognize the possibility that biological activity may have taken place. The author concurs with most of Young's (1951) observations.

Richter (1952) completed a detailed study of the Michipicoten Iron Formation and made the following observations which he interpreted to suggest replacement origin.

A. The siderite is sheared at the metavolcanic contact and therefore pre-deformation (p.18). (Note: At the Lucy pit structureless massive siderite lies in direct contact with fissile tuffs).

B. Relicts of host rock and host rock minerals are common in siderite (p.84).

C. Siderite bands in banded chert are discontinuous and masses and stringers of siderite are interconnected which is consistent with replacement (p.84).

D. Trace element content of the siderite suggests a magmatic origin (p.84).

E. Pyrrhotite in the iron formation is of high temperature origin which is consistent with a magmatic - hydrothermal origin (p.85).

F. Siderite and pyrite zones are of large areal extent. The siderite and pyrite are, however, not as extensive as the banded chert (p.85).

G. Siderite and pyrite do not crosscut the metavolcanic rocks (p.85).

H. Siderite texture is similar to later Paleozoic limestone (p.85).

I. Siderite occurs only at stratigraphic bottom of the iron formation unit (p.86).

J. Fine-grained siderite is the result of granulation of former coarse-grained siderite (p.86). (Note: Coarse-grained siderite within and marginal to quartz veins megascopically does not show evidence of granulation nor do the veins themselves display evidence of deformation).

K. The siderite, in places, is highly brecciated, the fragments being recemented with chlorite (p.86) (Note: This feature was not observed by the author).

L. Late veins cut the iron formation and lack evidence of deformation. The veins consist largely of coarse-grained carbonate and quartz (p.86). (Note: At the Lucy pit these veins are restricted largely to the carbonate and sulphide facies and do not extend into the enveloping metavolcanic rocks. The author considers these quartz-filled fractures to represent channels along which flowed silica-bearing fluids to the upper part of the iron formation during the later silica depositional stage of iron formation deposition).

M. Banding in the tuffs could be either original bedding or a schistosity developed prior to replacement (p.87).

On the basis of his observations Richter (1952, p.87, 88) proposed that the Michipicoten Iron Formation (siderite plus pyrite) is a replacement deposit rather than a primary sediment. The replacement took place while the chert was flat lying by magmatically derived hydrothermal fluids rich in iron, carbon dioxide and sulphur. As a consequence of the replacement process silica, alumina and K_2O were removed (Richter 1952, p.89). The chert is a sedimentary unit and the siderite and pyrite are replacement bodies. Richter (1952, p.88) proposed three major factors in forming these deposits: 1) a ponded structure wherein banded chert was deposited 2) a porous host rock (underlying tuffs) and 3) an hydrothermal solution of appropriate physical and chemical composition. The author considers the reasons cited by Richter (1952) for the replacement origin of the Michipicoten Iron Formation as not being exclusive to the replacement model. The reasons cited can be interpreted using a sedimentary model and same, in the authors opinion, are more supportive of a primary sedimentary model.

In 1953, Douglas (p.310) proposed that the pyrite associated with the Michipicoten Iron Formation at Goudreau was a hydrothermal replacement deposit. Douglas (1953, p.310, 314) used arguments of previous workers to support his proposal. The Algoman granites were proposed to be the source of the hydrothermal fluids causing replacement (Douglas 1953, p.310).

Over a period of years A.M. Goodwin has published a series of papers dealing with the origin of the Michipicoten Iron Formation.

Goodwin (1961, p.28) considered the Michipicoten Iron Formation to be directly related to Archean volcanism. The iron formation was deposited rapidly at the end of a mafic-felsic volcanic cycle implying an end stage magmatic differentiation process for the iron source (Goodwin and Shklanka 1967, p.792). The iron formation is a sedimentary deposit of volcanic origin derived by hot spring fumarolic or similar exhalative activity and the chert is analogous to sinter in a modern day hot spring (Goodwin 1964, p.648, 1973, p.915, 1961, p.26). The iron formation overlies intermediate to felsic metavolcanic breccia suggesting that

highly explosive volcanism preceded iron formation deposition (Goodwin 1964, p.712). Iron formation deposition is therefore rapid and occurred during a period of volcanic quiescence (Goodwin 1962, p.579, 1966, p.57). The iron formation is therefore an integral part of the volcanic cycle with the CO₂, Fe and S of magmatic origin and silica derived from leaching of the metavolcanic rocks (Goodwin 1962, p.579, Goodwin and Shklanka 1967, p.792). The volcanic exhalations of bicarbonate and sulphur varied intermittently across the area and precipitation depended on P, T, pH, Eh, salinity, biogenic activity and concentration of the precipitating elements (Goodwin and Shklanka 1967, p.792; Goodwin 1964, p.712). Deposition of the exhalative material preceded selectively from west to east under shore to depth environmental control (Goodwin and Shklanka 1967, p.792). The iron formation varies from oxide in the west to sulphide in the east and there is a transitional relationship from a sedimentary in the west to volcanic environment in the east (Goodwin and Shklanka 1967, p.782, Goodwin 1973, p.915). The presence of a shallow water, sedimentary environment in association with iron formation in the west; a deep water volcanic environment in the east is not supported by the present mapping. (The reader should refer to the section "Iron Formation-Environment of Deposition" for the author's comments). Goodwin (1964, p.714; 1962, p.579) interpreted the thickened section of iron formation at the Helen Iron Range to reflect deposition in a topographic low above a pyroclastic sequence of mixed composition and infers a similar relation for the Josephine Iron Range immediately northeast of the map area. The reader should refer to the structural geology section of this report for additional comments concerning the thick iron formation at the Helen Iron Range. Goodwin (1961, p.26) found anomalous B and As content in the footwall rocks and cites this in support of a hot spring origin for the iron formation. Goodwin (1964, p.712, 1973, p.915, 931) interpreted the felsic metavolcanic rocks as being of island arc-type and suggests that Archean volcanic basins represent the expression of Archean thermal plumes or hot spots.

Goodwin et al. (1976), Thode and Goodwin (1983) and Goodwin et al (1985) completed detailed isotopic studies on carbon and sulphur isotopes from samples collected from the Michipicoten Iron Ranges. The sulphur and carbon isotopes are consistent with the existence of autotrophic organisms and reducing bacteria in Archean time.

Goodwin et al. (1976, p.889) concluded that volcanic gases are an unlikely direct source for the sulphur and that bacterial reduction of seawater sulphate to H₂S is the most likely method of generating the sulphide deposits found in the Michipicoten Iron Formation.

The banding in the iron formation is interpreted by Goodwin et al. (1976, p.888) to represent intermittent flow of ferrous iron into the basin where the carbonates and sulphides were deposited. The basin of deposition was considered to be restricted and subjected to changing physical conditions (Thode and Goodwin 1983, p.352).

A $\delta^{13}\text{C}$ isotopic shift of 27.1 ‰ between sideritic and graphitic carbon is considered by Goodwin et al. (1976, p.870) to be characteristic of a shift between marine carbon and organic carbon. The carbon isotope data is also consistent with autotrophic biological activity in deposition of the iron formation and suggests a possible role of photosynthesis (Goodwin et al. 1976, p.888). Later studies by Thode and Goodwin (1983, p.350) indicated that the carbon is from both marine and organic sources. Thode and Goodwin (1983, p.351) suggested deep circulation of seawater and reaction with basaltic rocks generated the hydrothermal fluids that deposited the iron formation. Seawater SO_4^{2-} is reduced to H_2S by interaction with basaltic rocks at 250°C , possibly by the leaching of ferrous iron from the rocks (Thode and Goodwin 1983, p.351). Thode and Goodwin (1983, p.351) concluded that at high temperature, isotopic exchange between H_2S product and residual SO_4^{2-} in seawater is reduced and therefore the reaction produced H_2S has the same isotopic $\delta^{34}\text{S}$ value as found in the initial seawater sulphate. The only large scale process for sulphur isotope fractionation is bacterial reduction of sulphate (Thode and Goodwin 1983, p.352).

Goodwin et al. (1985) presented an additional interpretation of the 1983 (Thode and Goodwin) isotopic data. They proposed that volcanic fumarolic activity involving Archean seawater containing Fe, CO_2 , SiO_2 , SO_4^{2-} , HCl, HF, N, P and K formed the Michipicoten Iron Formation. The HCl and HF controlled the pH of the fluid and N, P and K provided nutrients to autotrophic organisms and reducing bacteria which controlled the Eh (Goodwin et al. 1985, p.82). They proposed that three internal cycles of seawater-bearing volcanic exhalations formed the Helen Iron Range. The three cycles represent repetition of siderite-pyrite and chert units at the MacLeod Mine at the west end of the Helen iron range and were identified by cyclic variation in the sulphur isotopes up the stratigraphic section (Goodwin et al. 1985, p.81). The three rhythmic cycles took place within a megacycle represented by the Michipicoten Iron Formation which is characterized by decreasing carbonate and increasing silica up section (Goodwin et al. 1985, p.81).

The cyclic variation in $\delta^{13}\text{C}$ is likely controlled by the batch process or flow of fresh seawater into the basin (Goodwin et al. 1985, p.79). This seawater influx would influence the pH and nutrient inflow which controls biological activity and thus Eh. Goodwin et al. (1985, p.72) proposed that the Michipicoten Iron Formation formed in a subaqueous cauldron subsidence basin.

Karkhanis et al. (1980, p.1,7) identified organic compounds within the iron formation. For further information, one should refer to the Organic Geochemistry section in this chapter.

LeSeelleur (1980) completed a detailed alteration study at the Lucy Iron Range. Most of his data is given in the section "Metamorphism and Alteration" within this report.

The fluid that deposited the iron formation was Archean seawater with a significant contribution from *metamorphic outgassing of a CO₂-rich fluid* (LeSeelleur 1980, p.59, 61, 72, 74). The seawater circulated to depths of 2 to 3 km where it was heated to moderate temperatures greater than 200°C (LeSeelleur 1980, p.61). LeSeelleur (1980, p.62) proposed that the seawater upon descent promoted hydration and oxidation of the metavolcanic rocks and added Na, Mg and the complexes CO₃= and SO₄= to the metavolcanic rocks to form chlorite, albite, anhydrite, Mg-rich smectites and sulphides. The fluid from which the iron formation was deposited was from a mafic source or had reacted with a mafic rock assemblage during its movement (LeSeelleur 1980, p.72). LeSeelleur (1980, p.62, 72) interpreted the rock assemblage to result from an exchange of Si, K, Na, with Fe, Mg and OH⁻ and some Al with SiO₂⁻ undersaturated and CO₂-rich fluid. The CO₂-rich fluid mixed with seawater to transfer the iron derived from alteration of the volcanic rocks to surface. The alteration of the highly permeable footwall rocks is conformable to the iron formation and is of regional extent representing a defocused hydrothermal system of high fluid/rock ratio at a temperature of approximately 180°C (LeSeelleur 1980, p.74). The pervasive alteration is low temperature and rare metal (W and Ag) separation indicates a defocused system implying a lower fluid convection than a found in a focused system (LeSeelleur 1980, p.56, 70). The high carbonate content of the metavolcanic rocks at the Lucy Iron Range may indicate limited seawater mixing with the CO₂-rich fluid that formed the iron formation (LeSeelleur 1980, p.72). LeSeelleur (1980) recognized the possibility that the iron composing the iron formation is a result of alteration of the volcanic rocks at depth. The high magnesium and iron thoeilites are an excellent source for this iron. This interpretation contrasts with Goodwin (1967) who proposed a magmatic origin for the iron. The author concurs with LeSeelleur (1980)

MacMillan (1981) examined the chloritoid alteration below the Helen Iron Range and related the alteration and formation of the iron formation to volcanic fumarolic activity. Deposition was at the rock-water interface and using criteria established by Large (1977) the iron formation is considered by him to be proximal to its source. The hydrothermal fluid flow was defocused and experienced low convective flux (MacMillan 1981, p.40-42).

MICHIPICOTEN IRON FORMATION ORIGIN - SUMMARY

The regional extent of the Michipicoten Iron Formation, the consistent stratigraphic position within the volcanic stratigraphy, the consistent vertical facies variation independent of structural attitude, the presence of good primary sedimentation features within the iron formation, the presence of abundant carbonaceous material and the presence of bulbous, oval

and thin laminae of sulphide which morphologically is more consistent with a biogenic origin than replacement or strict chemical deposition, all support a primary depositional origin for all facies of Michipicoten Iron Formation. The replaced metavolcanic detritus found within the iron formation was washed into the depositing iron formation or was air fall material that settled into the iron formation through the overlying water column. The presence of metavolcanic detritus, within the iron formation should not be considered unusual but to be expected. The iron formation represents a mixed chemical and clastic sediment with the clastic portion increasing stratigraphically upward. The presence of graded bedding and conformable interformational slump breccias likely triggered by earthquake activity indicate deposition in a subaqueous environment below wave base on a paleoslope of unknown dip in a tectonically unstable environment. Primary textures in the metavolcanic rocks above and below the iron formation, the metasedimentary rocks above and the hydro explosion breccias below all indicate low pressure or shallow water conditions. The increasing content of carbonaceous material stratigraphically upward indicates increasing biological activity towards the stratigraphic top. The vertical variation in iron formation facies is due to a changing fluid composition and changing biological activity with time in response to changing physical and chemical conditions. The low temperature (200°C) hydrothermal fluid that deposited the iron formation was a mixture of deep convecting seawater and CO₂-rich metasomatic fluid representing defocused, tortuous discharges at the seafloor.

The major elements forming the iron formation (Si, Fe, Mn) with the exception of the CO₂, have all been leached from the underlying metavolcanic rocks with the high iron and magnesium tholeiitic lavas lying below the permeable intermediate to felsic metavolcanic rocks, a most likely source for the iron. The major element source is therefore non-magmatic and the iron formations are a metasomatic product of deep circulating seawater altering the intermediate to mafic volcanic rocks and metamorphic carbon dioxide degassing. The iron formation is an integral part of the volcanic stratigraphy and is a direct product of the magmatic-metamorphic evolution of the Wawa supracrustal sequence. The Michipicoten Iron Formation represents a hiatus in volcanic activity during which chemical and clastic sedimentation took place before the start of cycle two volcanism. Biological activity in the hot (discharging) to warm hydrothermal fluids played a major role in iron formation deposition by reducing seawater sulphate to hydrogen sulphide permitting deposition of the large quantities of sulphide found in the iron formation. Deposition below wave base in a low pressure (shallow water) environment implies a basin of restricted extent.

INTERMEDIATE TO MAFIC INTRUSIVE ROCKS (MAP UNIT 6)

Intermediate to mafic intrusive rocks are abundant in the Wawa supracrustal rocks. They are undoubtedly of more than one age, however, the age relations are largely speculative.

MAFIC INTRUSIONS IN CYCLE ONE INTERMEDIATE TO MAFIC METAVOLCANIC ROCKS

Mapping of cycle one intermediate to mafic metavolcanic rocks routinely noted many outcrops of medium-grained, massive mafic rock which could either be thick flow centres or intrusions. If outcrops of undoubted extrusive rock occurred in proximity to an outcrop of more doubtful genesis the exposure was usually incorporated with the extrusive rocks and considered to be a massive flow. If the outcrop was one of many in a reasonably large area of outcrop interpreted as intrusive, it was coded with the intrusions. Intrusions of this group are interpreted to have likely been intruded concomitantly with deposition of the associated metavolcanic rocks and were possibly feeders for some of the flows. Undoubtedly some mafic intrusions cut across the intermediate to mafic part of first cycle volcanic rocks to serve as feeders to second cycle volcanic rocks and thus do not belong in this group, but there is no reliable means of separation.

Thin sections of widely separate units were examined. The texture is fine- to medium-grained, seriate. Relict diabasic texture is present in one sample. In thin section, amphibole, chlorite, plagioclase, quartz, opaques and leucoxene were observed in widely varying amounts.

Samples of mafic intrusive rocks were collected for analyses throughout the map area. The AFM diagram (Figure 39) indicates these samples are somewhat iron-enriched while the cation plot (Figure 40) indicates most are high-magnesium tholeiites with subordinate high-iron tholeiites. Two basaltic komatiite samples were identified: one (79-6480) from Owens Lake (local name) and the other (83RPS-0161) from east of Holdsworth Lake.

MAFIC INTRUSIONS WITHIN THE FOOTWALL OF THE MICHIPICOTEN IRON RANGES

Below the Helen, Eleanor and Lucy iron ranges large almost sill-like mafic intrusive bodies exist. The mafic intrusion below the Helen Iron Range is approximately 500 m thick and numerous crosscutting dike-like apophyses project from the main intrusive mass. The sill-like bodies are reported by Goodwin (1962) to occur at a 15 to 20° oblique angle with

the stratigraphy and the author has confirmed this low angle crosscutting relationship in regional mapping. The small dike-like projections are often extensively altered to carbonate plus chlorite and may be so altered as to consist of up to 40% carbonate porphyroblasts in a reddish brown-weathering chlorite matrix. The footwall intrusions to the Helen and Lucy iron ranges are much easier to recognize than those in the lower mafic part of the first cycle since their mafic composition contrasts with the intermediate to felsic footwall rocks.

Intrusions of this group cut across the iron formation in the Helen and Lucy iron ranges and conceivably are feeders for cycle two intermediate to mafic metavolcanic rocks. In the Helen Iron Range, these intrusions are reported to cut out a large quantity of ore in the old Helen Mine (Moore and Armstrong 1946, p.97). The mafic intrusions northwest of the Helen Iron Range near Legarde Lake are considered to be part of this group of mafic intrusions that were folded and faulted to a position above the Helen Iron Range. Goodwin (1964, p.687, 689) reported that the volume of mafic intrusive rocks increases to the west. In the case of the footwall intrusions, they do appear to increase in abundance moving west from the Josephine to the Helen Iron Range. Large deformed footwall intrusive rocks, however, are present within intermediate to felsic metavolcanic rocks in Corbiere Township and large intrusive bodies occur in Agounie Township east of the McVeigh Fault. The westward increase, therefore, may not actually exist when considering the entire belt.

In the case of the Helen Iron Range, Kidder and McCartney (1946, p.12, 17, 18) advocate mafic intrusion and replacement of the pyroclastic rocks before schistosity development. They also reported that the siderite replaces the intrusions. No other investigator has reported such a replacement relationship and their siderite may be the yellow brown weathering rhombi of ankerite that commonly occur in altered mafic intrusive rocks throughout the Wawa area.

Osterburg (1982, p.38-40) reported four ages of mafic intrusion in the footwall rocks of the Helen Iron Range. The two oldest were described as quartz-bearing gabbro and quartz-bearing pyroxene-hornblende gabbro.

The author can not substantiate the subdivision of Osterburg (1982) and considers the two oldest to be part of the footwall intrusions and the two youngest are possibly much younger diabase. The quartz-bearing gabbro is described as a medium-grained hypidiomorphic rock consisting of 60% carbonate, 8% quartz and 7% plagioclase (Osterburg 1982, p.38, 40). He described the quartz-bearing pyroxene-hornblende gabbro as fine- to medium-grained hypidiomorphic and ophitic and composed of 40% plagioclase (An44), 40% altered pyroxene, 5% quartz and 5% amphibole.

Nebel (1982) examined a stratigraphic section adjacent to Osterburg (1982) below the Helen Iron Range and did not recognize four ages of mafic intrusions. The author concurs

with Nebel (1982). Nebel (1982, p.60) classified the intrusions as dikes and sills of diorite. The author concurs with this classification. He observed the main sill to vary from 275 to 880 m in thickness. Nebel (1982, p.63) does not give modes but reported that the main intrusion consists of actinolite, possibly after pyroxene, plagioclase altered to sericite, chlorite and clay. He interpreted the presence of some clay to be after potassium feldspar and reported minor quantities of quartz, apatite, pyrite and chalcopyrite. He observed a zone of magnetite enrichment within the sill.

Nebel (1982, p.63) described related sills and dikes related to the main sill as consisting of plagioclase altered to sericite, chlorite, quartz, sericite, with traces of pyrite and disseminated leucoxene or ilmenite. He also reported that some fine-grained dikes and sills may contain up to 2% plagioclase phenocrysts and a rare quartz grain up to 1 mm in size.

At the Lucy Iron Range, Eden (1980, p.36, 37) described the mafic intrusion as diorite consisting of corroded and sericitized plagioclase laths, clot-like aggregates of fine-grained chlorite and up to 30% fine-grained rhombi of ankerite. He also reported equant subhedral quartz grains and elongate ilmenite grains.

Eden (1980, p.37) observed coarse-grained pyrite in association with irregular quartz-ankerite patches and veins. Eden (1980, p.37) reported that the leucocratic phases are more massive and consist of sericitized feldspar, ankerite and subordinate chlorite. Quartz and ilmenite are common in the leucocratic phase. Eden (1980, p.36) reported the intrusion is crudely zoned from more mafic chlorite-rich borders to a more leucocratic core.

Abercrombie (1981, p.49) described the mafic intrusion below the Lucy Iron Range as a gabbro sill up to 180 m thick. Abercrombie (1981) reported that the mineralogy consists of euhedral magnetite, andesine altered to sericite, chlorite, carbonate and epidote.

In the field, the large mafic intrusions below the iron ranges are massive, medium- to coarse-grained and weather black, greenish black, or green. Local coarsening to form pegmatitic segregations may occur but is uncommon. Dikes and sills branching off from the main intrusions weather green to light green and may display a pronounced pitting due to the weathering out of euhedral, orange-brown carbonate rhombi. The rhombi may be as large as 3 mm and compose nearly half the rock. A rusty brown weathered rim 1 to 2 cm thick may occur on heavily carbonated rocks. Blue opalescent quartz is a common but very minor mineral phase in some intrusions.

One sample of the mafic intrusion below the Helen Iron Range was thin sectioned. The rock displays a fine-grained, massive, seriate, granoblastic texture. The mineralogy was estimated to be 30% chlorite, 15 to 20% amphibole, 20 to 30% plagioclase and minor amounts of epidote, opaques, quartz and sericite.

The chlorite is fine-grained and tabular. The amphibole (possibly actinolite) forms acicular crystals. Plagioclase occurs as small untwinned grains altered to sericite. Minor quantities of anhedral quartz with wavy extinction occur in the groundmass.

Figures 41 and 42 are respectively AFM and cation plots of mafic intrusive rocks in the footwall of the Michipicoten Iron Formation. The AFM plot displays an iron-enrichment trend and the cation plot shows a clustering around high magnesium tholeiite. A fairly significant number of samples also fall into the high-iron tholeiitic basalt field on a cation diagram. No consistent variation in composition was noted with stratigraphic position of the intrusions.

REED LAKE MAFIC STOCK

A large but poorly outlined mafic intrusion is present at Reed Lake in the southeastern corner of McMurray Township. The rocks of the complex are massive, medium to locally coarse-grained and weather green and dark green. Those rocks are rich in plagioclase and are mottled grey-buff and green. Blue opalescent quartz is common in the plagioclase-rich phases. Locally, shearing is common. The main body of the Reed Lake Mafic Stock is crudely oval in shape and elongated in a northwest-southeast direction.

Extending northwest from the Reed Lake area to the Jubilee Stock are numerous outcrops of fine- to medium-grained igneous rock of widely varying composition. The Reed Lake Mafic Stock and Jubilee Stock may be connected or related. The Jubilee Stock has been dated at 2745 ± 3 Ma. by U-Pb techniques (Sullivan et al. 1985). The 315° trend of the long axis of the Reed Lake Mafic Stock, combined with the 20° trend of the long axis of the Jubilee Stock, may suggest that these intrusive bodies occupy a conjugate fracture pattern. The 315° trend is common in both transverse faulting and diabase dike intrusions. In thin section, rocks of the Reed Lake Mafic Stock are fine- to medium-grained, seriate and granoblastic. Samples of quartz gabbro to gabbro were estimated to contain 10 to 20% quartz, 20 to 40% amphibole and 40 to 60% plagioclase. Minor quantities of sphene, opaques and chlorite were noted and one sample contains 10% biotite.

Samples mapped as pyroxenite were estimated to contain 0 to 10% biotite, 15 to 25% quartz, 40 to 55% amphibole (after pyroxene) and 0 to 30% plagioclase. Minor chlorite, sericite and opaques are present.

The only mineralogical difference between the rocks mapped as gabbros and those rocks mapped as pyroxenites is the plagioclase to amphibole (after pyroxene) ratio.

The quartz occurs as anhedral, interstitial, unstressed grains and may be the product of alteration rather than a product of magmatic crystallization.

The amphibole occurs as anhedral, ragged, prismatic grains. The cores of the larger grains are pleochroic in brown and the rims are pleochroic in green. The amphibole is altered to actinolite. Pyroxene rimmed with amphibole was observed in one sample.

Plagioclase is subhedral to euhedral, tabular in form and extensively saussuritized. Relict albite twinning is present in some grains but most grains are untwinned. The plagioclase occurs in association with chlorite, sericite and epidote. A reliable determination of plagioclase composition by optical methods was not possible.

Biotite is present in some samples as brown, ragged, anhedral grains. Biotite may be a secondary rather than a primary mineral phase.

AFM and cation plots of the Reed Lake Mafic Stock indicate a moderate to weak iron-enrichment trend and a very wide range of compositions from basaltic komatiite to basalt (Figures 43 and 44). The composition of some, if not most, of the rocks such as pyroxenites, are not likely to approximate magma compositions so comparison with other plutonic or volcanic rocks speculative. Comparing these diagrams with those of the Jubilee Stock indicate that if these two bodies are related, the intrusive phases of the two intrusions are compositionally different. If they are related and of the same age, the mafic stock could conceivably be a feeder for some of the cycle two mafic metavolcanic rocks. The stock, however, displays a much stronger komatiitic trend than cycle two volcanic rocks. The apparent differences in the komatiitic trend is possibly a function of processes other than crystal fractionation.

OLD DIABASE

In McMurray Township, a number of sinuous linear mafic bodies have been referred to as old diabase (Collins and Quirke 1926, p.37; Matheson 1932, p.51, 52, 53, 1933, p.8, 9; Froberg 1935, p.44). The old diabase is considered by the author to be Archean in age and these linear mafic bodies have not been recognized in other parts of the map area. They are probably equivalent to the footwall mafic intrusions. The dikes strike northwest at approximately 315° subparallel to the zone of intrusive rocks between Jubilee Stock and Reed Lake Mafic Stock. The old diabase dikes cut the granitic rocks of the Jubilee Stock. The dikes appear to dip vertically to subvertically and pinch and swell rapidly along strike presenting sinuous contacts. The dikes have been deformed after emplacement. Dike widths exceeding 30 m have been observed. Matheson (1932, p.51-53) gives the most complete description of these rocks. The author did not prepare thin sections from this group of mafic intrusions due to their limited spatial distribution. In the area of the Parkhill Mine, young diabase appears to have been emplaced along the same fracture as the old diabase.

The old diabase occupy a very old fracture system that underwent later reactivation during a younger diabase emplacement event. Collins and Quirke (1926, p.37) described the old diabase as highly altered and difficult to subdivide from greenstone. On this basis, the author classifies these rocks as Archean. They observed sharp sinuous contacts and described the rock as being composed of hornblende, plagioclase, epidote, leucoxene and other alteration minerals. The author concurs with Collins and Quirke (1926) that the old diabase would be difficult to subdivide from metavolcanic or mafic intrusive rocks if it occurred within the intermediate to mafic portion of the various volcanic cycles. The old diabase appears identical in texture and composition to Archean mafic intrusive rocks mapped by the author in other parts of the Michipicoten supracrustal belt.

Matheson (1933 p.8, 1932, 52) and the author have observed that the old diabase is cut by younger diabase which is much more abundant than the old diabase in the vicinity of Wawa. Matheson (1933 p.9, 1932 p.52) observed sheared chilled margins on the dikes and reported that some contain euhedral feldspar phenocrysts up to 1.25 cm in size. The author has also observed possible chill margins on these dikes but not feldspar porphyritic textures. The original mineralogy is approximately 50:50 plagioclase and pyroxene and Matheson (1933 p.9, 1932 p.53) reported some quartz and carbonate veinlets cutting the dikes. A diabasic texture was not observed in the field by the author and is reported to be uncommon by Matheson (1932 p.53).

Matheson (1932 p.53) reported the rock to contain 50 to 70% plagioclase altered to epidote, zoisite, quartz and sodium plagioclase, 35 to 50% augite altered to uralite and chlorite. He reported accessory ilmenite, quartz and apatite and considers the quartz to be a product of alteration. He also reported the presence of quartz intergrown with plagioclase. Plagioclase phenocrysts are totally altered to epidote, zoisite, chlorite and quartz and have diffuse boundaries with the groundmass (Matheson 1933 p.53). Matheson (1932 p.54) reported that old diabase on Dore Point west of the map area is cut by 7.5 to 10 cm wide aplite dikes of syenite which are confined to the old diabase. Matheson (1932 p.54) interpreted the aplite as differentiates (granophyre) of the old diabase. The author has not examined the outcrop described by Matheson (1932). Froberg (1935, p.44) observed that gold-bearing quartz veins cut the old diabase.

SUNRISE LAKE MAFIC TO ULTRAMAFIC INTRUSION

The Sunrise Lake Mafic to Ultramafic Intrusion is one of the more interesting mafic intrusions in the Wawa supracrustal rocks since it contains significant disseminated copper, nickel and platinum group element mineralization. The intrusion has been subjected to

intense exploration but detailed studies of the mineralogy are lacking. Exposure of the complex is relatively poor and most of the intrusion is covered by the waters of Sunrise and Elbow lakes. The long axis of the body strikes northwest at approximately 280° and sharply crosscuts the northeast-trending supracrustal rocks. It crosscuts a lower mafic metavolcanic section that is in part basaltic komatiite in composition and also cuts calc-alkalic intermediate to felsic metavolcanic rocks of subcycle one. The intrusion could not be traced as far as Loonskin Lake. The Sunrise Lake Mafic to Ultramafic Intrusion is one of the more intensely metamorphosed mafic intrusions in the region and could conceivably be one of the oldest mafic intrusion in the area. The intrusion is approximately 2700 m long and 700 m wide. If this intrusion was a dike-like body emplaced before the northwest-facing stratigraphy was folded into a subvertical position, the sulphide mineralization at the eastern end of the body would have originally been at the bottom of the intrusion. Exposed contacts are rare and restricted to the southern margin of the intrusion. One contact was observed to dip vertically a second at a moderate angle to the north. Moore (1946, p.119) reported that diamond drilling indicates that the associated sulphide mineralization dips 43° to the south. Outcrops of the mafic intrusion weather green and are generally smooth with the exception of several outcrops at the western end of Sunrise Lake which have a knobby weathered surface.

In thin section, the rock contains principally chlorite, actinolite, serpentine and talc. Other minerals are opaques and carbonate. One specimen contains up to 25% subhedral to rounded olivine grains altered to serpentine and talc. Another specimen contains 30% plagioclase of An₅₄ content that partially encloses actinolite. The actinolite occurs as acicular prismatic grains and may enclose serpentinized olivine. The chlorite occurs as ragged tabular grains that are larger than the other minerals. The chlorite may be after pyroxene and may enclose altered olivine imparting a sieve texture to the rock. The talc occurs as fine-grained interlocking mats, possibly after olivine. The outcrop with knobby weathering contains anhedral pyroxene grains poikilitically enclosing olivine. The knobs are clots of relatively unaltered pyroxene. In addition to the mineralogy observed by the author, Moore (1946, p.120) reported the presence of hornblende and biotite. The opaques were identified as magnetite, pyrrhotite and chalcopyrite and one thin section examined is reported to contain scapolite (Moore 1946).

A suite of samples were collected for analysis and plotted on AFM and cation diagrams (Figures 45 and 46). The AFM diagram displays a magnesium-rich suite and the cation plot shows a dominantly ultramafic komatiite and basaltic komatiite suite. Two samples from the northern side of Sunrise Lake have basaltic and/or andesitic compositions. These two samples could be from mafic intrusions within the intermediate to mafic

metavolcanic rocks of cycle one enclosing the intrusive body and thus unrelated to the Sunrise Lake Mafic to Ultramafic Intrusion.

LATE PERIDOTITE-PYROXENITES

At Lena, Mildred and Bauldry Lakes within the map area and at Endless Lake, Corbiere Township north and adjacent to the map area small peridotite-pyroxenite intrusions are present. As a group, these intrusions are less altered than the Sunrise Lake Mafic to Ultramafic Intrusion and appear to occur along segments of the Magpie River Fault where it has been cut by northwest-trending transverse faults. The author considers these intrusions to be younger and unrelated to the Sunrise Lake Mafic to Ultramafic Intrusion even though a relationship has been suggested by Moore (1946, p.78, 79).

The freshest outcrops weather black to green black and display a rough, jagged to pitted surface. The Lena Lake peridotite body may be approximately 650 m in diameter but is poorly exposed, lying mostly beneath the waters of Lena Lake. The Mildred Lake peridotite is approximately 900 by 200 m with its long axis oriented in a east-west direction parallel to the interpreted strike of the Magpie River Fault. Exposures are largely limited to the north part of the lake and a large part of the body may lie beneath the waters of Mildred Lake. Numerous highly carbonated, fine-grained, narrow, mafic dikes cut the clastic metasedimentary rocks east of Mildred Lake and may be highly altered equivalents of the intrusion on Mildred Lake.

At Bauldry Lake, the peridotite is approximately 600 by 200 m and is very poorly exposed. It is oriented east-west and was likely emplaced along a branch of the Magpie River Fault. The peridotite body at the eastern end of Endless Lake is small and poorly defined.

The relative size of these peridotite-pyroxenite intrusions diminishes as one moves eastward along the faulted segments of the Magpie River Fault.

In the field, these intrusions may contain large, 1 cm or greater, chloritized, poikiloblastic biotite grains. Cleavage reflections on broken surfaces indicate oikocrystic grains of altered pyroxene up to 1 cm with abundant tiny round poikocrysts which were assumed to be olivine.

In thin section, the rock displays a fine- to medium-grained, seriate texture.

The mode of one sample from Lena Lake was estimated as 15% serpentine, 50% amphibole, 10% chlorite, 15 to 20% olivine, 10% clinopyroxene and minor opaques. The chlorite occurs as large anhedral grains that may enclose fine-grained opaque Fe-Ti oxides. The serpentine is present as fine-grained radiating aggregates. Olivine forms subhedral to

rounded grains altered to chlorite and serpentine and are stained with iron oxides. Amphibole is present as acicular crystals with a random orientation. The clinopyroxene displays good cleavage and has altered to both chlorite and amphibole. The Fe-Ti oxides occur as tiny rectangular euhedral crystals. The Lena Lake Intrusion is reported to contain asbestos on a island in Lena Lake (Rupert 1979, p.158) but this occurrence was not be located during this project.

Two thin sections of the Mildred Lake peridotite indicate an estimated 10 to 15% serpentine, 35 to 40% olivine, 5 to 10% talc, 10% chlorite, 30 to 35% clinopyroxene and traces of Fe-Ti oxides. The serpentine occurs in veins and aggregates. The chlorite forms large anhedral, tabular booklets with abundant inclusions of serpentinized olivine. The chlorite is after pyroxene and is undoubtedly the oikocryst while the olivine inclusions are the poikilocryst observed on fresh surfaces.

Olivine is present as rounded to subhedral grains altered to serpentine and is enclosed in chlorite after pyroxene resulting in a sieve texture. Pyroxene, where present as relict grains, is anhedral, oikocrystic and contains abundant olivine. Minor talc is present as fine-grained tabular grains.

One thin section was prepared from the Bauldry Lake peridotite and this contains an estimated 20% chlorite, 45% amphibole, 15 to 20% carbonate and 20 to 25% plagioclase. The chlorite occurs as large anhedral tabular grains with some kinking of the cleavage. The chlorite appears similar to chlorite at Lena and Mildred lakes and may be after pyroxene. Carbonate is anhedral and interstitial. The amphibole occurs as prismatic crystals, some of which display twinning and has ragged ends.

The plagioclase forms anhedral interstitial grains altered to carbonate, epidote and sericite. The plagioclase has a composition of at least An₃₄.

While appearing identical in the field to the other intrusions the Bauldry Lake intrusion displays a tendency towards being more like a pyroxenite or gabbro rather than peridotite.

AFM and (Figures 47 and 48) cation plots of these peridotites indicate a high-magnesium group of rocks that fall into basaltic komatiite and ultramafic komatiite fields. Two samples are from Lena Lake, two samples are from Mildred Lake two samples are from Bauldry Lake and one sample is from Endless Lake. A magnetitic anomaly known as Wagner's Anomaly 14b at the southern end of Goetz Lake may indicate the presence of another peridotite intrusion which would also be associated with the Magpie River fault system (Macauley 1962b).

FELSIC INTRUSIVE ROCKS (MAP UNIT 7)

The felsic intrusions can essentially be subdivided into three groups: quartz-feldspar porphyries and the granitic rocks of the Jubilee Stock. The quartz-feldspar porphyries in McMurray and Esquega townships cut cycle one and subcycle one metavolcanic rocks while a very small intrusion of leucocratic quartz-feldspar porphyry cuts second cycle metavolcanic rocks north of the Magpie River, in Chabanel Township.

HAWK LAKE GRANITIC COMPLEX

A massive medium- to coarse-grained leucocratic trondhjemite to quartz monzonite is present at the immediate contact of the supracrustal rocks and the granitic rocks in Esquega Township. This granitic mass is known as the Hawk Lake Granitic Complex. To the north it becomes increasingly more inequigranular and porphyritic. Septa and apophyses from this granitic mass are typically quartz-feldspar porphyries. The author considers the quartz-feldspar porphyry intrusions in the basal part of the first cycle volcanic rocks in Esquega Township to be related to the Hawk Lake Granitic Complex. The Hawk Lake Granitic Complex is fault bounded to the south by the Hawk Lake Fault and to the east it is cut off by the transverse Marsden and McVeigh Creek faults. Granitic rocks exposed in the southeast corner of Corbiere Township north of Hawk Junction are possibly the faulted eastern extension of the Hawk Lake Granitic Complex.

In thin section, the rock is medium- to coarse-grained equigranular massive, allotriomorphic to hypidiomorphic with straight to curved grain boundaries. The rock was classified in the field and in thin section as varying from trondhjemite to quartz monzonite in composition.

In thin section, the mode was estimated as 0 to 30% microcline, 45 to 65% plagioclase, trace to 5% biotite and 25 to 35% quartz. Trace to minor quantities of carbonate, sericite, zircon, garnet and epidote were recognized.

The microcline occurs in anhedral grains. It is interstitial, fresh and in some samples it displays a stringy perthitic texture. Carlsbad twinning is present in several grains.

Plagioclase of approximately An37 to An44 composition forms anhedral to subhedral grains. The plagioclase crystals are interlocking and in contrast to the fresh appearance of the microcline the plagioclase is saussuritized, being dusted with fine-grained sericite. Several samples display bent twin lamellae suggesting a locally developed protoclastic texture.

The biotite forms small tabular anhedral grains between the felsic minerals. The biotite also occur as an interlocking matte of several grains and may display some alteration to chlorite.

The quartz occurs as an interlocking mosaic of anhedral grains. The quartz displays only weak undulatory extinction and has a granoblastic appearance with straight grain boundaries.

A sample collected from the mouth of the adit on the former property of Regnery Mines Limited was isotopically dated by Turek et al. (1983 p.470, 1984, p.457) and gave a date of 2888 ± 2 Ma. The Hawk Lake Granitic Complex contains xenoliths of supracrustal rocks indicating that intermediate to mafic metavolcanic rocks of the lower part of first cycle volcanism (subcycle one) are older than 2888 ± 2 Ma.

Figures 49, 50 and 51, respectively, present AFM, cation and Streckeisen classifications of the Hawk Lake Granitic Complex. The AFM diagram indicates that all rock compositions are calc-alkalic and the cation plot would place all rock compositions in the field of rhyolite. A true Streckeisen plot uses modes not norms as used here. All data plotted on the Streckeisen diagram display a trend towards more evolved rocks than petrographic examination would indicate. The AFM and cation plots are given for the intrusive rocks so that an easy comparison of present chemical composition with the extensive rocks can be made and it should not be assumed that these plutonic rock compositions represent Archean felsic magmas.

On the Streckeisen diagram, normative plots indicate that the Hawk Lake Granitic Complex consists dominantly of granite followed by subordinate amounts of granodiorite and quartz-rich granitoids. The author would prefer to classify the rocks as quartz monzonites, granodiorites and trondhjemitites based on potassium feldspar-plagioclase ratios and follows the classification of Ayres (1972). The scatter of normative data based on rock chemistry indicate chemical heterogeneity within the Hawk Lake Granitic Complex.

QUARTZ-FELDSPAR PORPHYRIES

Quartz-feldspar porphyry represents a major lithologic unit in parts of Esquega Township and forms a major intrusive body in McMurray Township. The unit can be divided into leucocratic and melanocratic quartz-feldspar porphyries. The melanocratic, green quartz-feldspar porphyry is represented by the intrusion in McMurray Township that forms an arcuate body extending from Wawa Lake, across Highway 101 and south towards Reed lake. The unit varies in width, up to 500 m and extends southeast for a distance of approximately 8.0 km. Isolated patches of more leucocratic quartz-feldspar porphyry occur in the vicinity of

Bond Lake, McMurray Township. The darker quartz-feldspar porphyry typically displays blue opalescent quartz phenocrysts up to 5 to 6 mm forming 10 to 15% of the rock. Euhedral feldspar phenocrysts up to 2 to 4 mm form an estimated 30 to 35% of the rock. The darker colour is due to the presence of chlorite.

In thin section, the rock is fine- to medium-grained, hiatal, massive with a granoblastic groundmass. The mode is estimated as 5 to 10% carbonate, 35% plagioclase 5% quartz and 55% matrix.

The plagioclase phenocrysts are subhedral, twinned and extensively saussuritized.

Quartz is present as rounded polycrystalline grains with good cusped margins suggesting resorption. Carbonate is present as anhedral interstitial grains.

The matrix consists of a granoblastic mixture of 50% quartz plus untwinned plagioclase and 50% sericite that gives the rock a weak schistosity.

The melanocratic quartz-feldspar porphyry occupies a ring fracture enclosing the Jubilee Stock and has been altered and fenitized in proximity to the Firesand River Carbonatite.

The leucocratic quartz-feldspar porphyries are concentrated in Esquega Township where only very minor amounts of dark quartz-feldspar porphyry are present. The quartz-feldspar porphyries are common east of Sunrise Lake, southeast of McEwen Lake and south of the former Murray Algoma Mine. The quartz-feldspar porphyries in Esquega Township do not extend stratigraphically above the discontinuous unit of intermediate to felsic metavolcanic rocks that occur in a discontinuous band from the southwest corner to the north-central part of Esquega Township. These quartz-feldspar intrusions may be subvolcanic intrusions that were feeders for subcycle one intermediate to felsic metavolcanic rocks. The quantity of porphyry increases towards the margins of the Hawk Lake Granitic Stock. The porphyritic texture of the margins grades into the equigranular texture of the core plutonic rocks of the granitic complex. The quartz-feldspar porphyries occur as dike- and sill-like masses and cut all the supracrustal rocks of the lower part of subcycle one metavolcanic rocks. The Hawk Lake Granitic Stock has been dated by U-Pb techniques as 2888 ± 2 Ma. age and contains xenoliths of the lower part of subcycle one intermediate to mafic metavolcanic rocks (Turek et al. 1983, p.A70, 1984, p.457). The quartz-feldspar porphyry forming the arcuate unit enclosing the Jubilee Stock to it. The Jubilee Stock has been dated by U-Pb techniques as 2745 ± 3 Ma. (Sullivan et al. 1985). The quartz-feldspar porphyries of Esquega Township are likely much older and unrelated to those found in McMurray Township.

In thin section, the quartz-feldspar porphyries in Esquega Township are fine- to medium-grained, porphyritic-hiatal, hypidiomorphic. The mode is estimated as 15 to 25%

quartz phenocrysts, 15 to 30% plagioclase phenocrysts and 50 to 60% matrix. Minor quantities of epidote, sericite, microcline, chlorite, carbonate and biotite are present.

The quartz has anhedral, rounded, polycrystalline grains that may display cusped margins implying some resorption of the quartz. The quartz may have wavy extinction.

The plagioclase occurs as subhedral crystals that are extensively saussuritized. The crystals may occur as glomeroporphs and a weak zoning is sometimes present.

The matrix is a granoblastic mixture of quartz and untwinned plagioclase with minor sericite, epidote and biotite.

In the Arliss Lake area, an unusual quartz-feldspar porphyry occurs as a number of small intrusions in close proximity to the intermediate to mafic metavolcanic-metasedimentary rock contact, but is largely intruded by the metasedimentary rocks. The quartz-feldspar porphyry contains subhedral to euhedral quartz phenocrysts up to 1 cm in size set in a buff coloured matrix. The matrix may locally display a green tint due to the presence of epidote. The pervasive alteration has largely destroyed the feldspar phenocrysts but their altered relicts are occasionally recognizable. The saussurization of this porphyry is pervasive and intense. Quartz veining of some exposures is common.

In thin section, the Arliss Lake rock is fine- to medium-grained, seriate, hypidiomorphic. The mode is estimated as 15 to 20% quartz, 35% plagioclase and 45% matrix. Minor carbonate and epidote are present.

The quartz occurs as euhedral crystals to subrounded grains that are weakly fractured and unstressed. The plagioclase occurs as euhedral to subhedral extensively saussuritized grains. The cores of some plagioclase grains are completely altered to sericite. The matrix is a mixture of sericite and granoblastic quartz plus untwinned plagioclase.

AFM and cation plots and Streckeisen diagram were prepared from a collection of quartz-feldspar porphyries (Figures 52, 53 and 54). Samples 1 and 2 are from Owens Lake (local name), Sample 3 is from Arliss Lake, Samples 4 thru 14 are a cross-section of quartz-feldspar porphyries taken normal to stratigraphy from the Regnery Mine area to McEwen Lake and Samples 15 and 16 are from the quartz-feldspar porphyry intrusion along Highway 101. The porphyries fall into the calc-alkalic field and are rhyolites on a cation plot. Using normative mineralogy, the porphyries display considerable scatter and fall into the fields of granite, granodiorite and quartz-rich granitoids on a Streckeisen diagram. The chemistry indicates that, in general, the porphyries are more potassium-deficient and more silica-rich than the Hawk Lake Granitic Complex or Jubilee Stock. The rock compositions most likely represent crystal-liquid mixtures and caution should be exercised when extrapolating the rock compositions to magma compositions.

JUBILEE STOCK

The Jubilee Stock is an elongate mass of diorite to granodiorite trending 020° in the centre of McMurray Township. The intrusion is 6.0 km long and 1.3 km wide and contains numerous blocks and xenoliths of volcanic wall rock. The volcanic xenoliths may compose up to 50% of the exposed surface of the stock. The intrusion has been subjected to shearing and faulting. It has been dated by U-Pb techniques as 2745 ± 3 Ma. (Sullivan et al. 1985).

Along the eastern margin of the intrusion, intrusive breccia is common and contains numerous blocks of various metavolcanic rocks. Intrusive rocks close to the contact are fine-grained and it is often difficult to separate the fine-grained border of the intrusion from the volcanic wall rocks. The abundance of metavolcanic xenolithic blocks indicate the complex is exposed at a high structural level and makes mapping difficult because of rapid lithological changes over very short distances. Most, if not all, of the other felsic stocks in the Wawa area, are crudely oval in plan view and do not contain such an abundance of xenoliths. The extreme elongation of this intrusion suggests strong structural control for emplacement. The stock is enclosed in a thermal aureole of contact metamorphism indicated by the hard, massive, hornfelsed nature of the contact rocks and xenolithic blocks within the stock. The stock weathers pink to grey and displays a highly variable texture. A good porphyritic texture occurs in one phase of the stock but it is uncommon.

Numerous outcrops of intrusive rock occur between the Jubilee Stock and the mafic intrusion centered on Reed Lake. The author has suggested that a possible genetic relationship may exist between the two intrusions in this report.

Matheson (1933, p.5, 8) observed a zone of mixed rock around the stock where metavolcanic rocks alternate with intrusive rocks. He observed that the boundaries are generally not sharply defined and many apophyses extend into the enclosing metavolcanic rocks. He has observed that some outcrops are impossible to distinguish from felsic metavolcanic rocks. Where schistosity is present, it strikes parallel and conformable to the intrusion (Matheson 1933, p.5). Rare bedding in the metavolcanic rocks enclosing the stock strike roughly parallel to the outline of the stock. In the area of the Darwin Mine, Froberg (1935, p.43) indicated that the diorite of the stock is cut by "old diabase" and that it is in turn cut by pink granite. The author has not observed pink granite cutting the old diabase.

Matheson (1933, p.8) interpreted the Jubilee Stock to vary from diorite to granodiorite in composition and he suggests that sharp contacts on the xenoliths suggest little assimilation of the xenolithic blocks. The author has also observed numerous sharp angular metavolcanic-intrusive contacts and the lack of textural evidence for assimilation.

Gledhill (1927, p.12) classified the stock as diorite to granodiorite in composition.

Rupert (1979, p.31, 32) observed that the Jubilee Stock contains abundant xenoliths, has poorly defined contacts due to intermingling of metavolcanic and intrusive rocks and has a highly variable composition. He reported that in the workings of the Citadel Gold Mines Limited indications are that it is a multiple felsic intrusion displaying a medium-grained equigranular texture and grey to pink colour. The workings were unavailable for examination by the author at the time of mapping.

In thin section, the rock displays a fine- to medium-grained, equigranular to seriate, allotriomorphic to hypidiomorphic texture. The mode is estimated as 10 to 30% quartz, 40 to 55% plagioclase and 10 to 20% biotite. One specimen contains approximately 45% interstitial myrmekite. Trace to minor amounts of opaques and amphibole were noted. The quartz is anhedral, interstitial to the plagioclase, polycrystalline and displays wavy extinction. + Plagioclase (An₃₁?) forms subhedral to euhedral crystals extensively dusted with sericite. The biotite forms anhedral brown elongated grains. Gledhill (1927, p.12) reported carbonate and epidote alteration of the plagioclase and Rupert (1979, p.31) reported chlorite alteration of the mafic minerals.

AFM, cation and Streckeisen plots were prepared from Jubilee Stock (Figures 55, 56 and 57). The AFM diagram indicates calc-alkalic compositions and the cation diagram indicates rhyolite and dacite compositions in both the calc-alkalic and tholeiitic field. The Streckeisen diagram indicates granodiorite to quartz monzodiorite compositions. The Streckeisen diagram using normative mineralogy indicates more evolved compositions than what petrography would suggest.

FIRESAND RIVER CARBONATITE (MAP UNIT 11)

The geology of the Firesand River Carbonatite located in McMurray and Lastheels Townships has recently been described by Sage (1983a). This carbonatite occurs at the junctions of the strike-slip Wawa-Hawk Lake Faults and Firesand River Fault. The geology of the complex has been described in abstract form by Sage (1983a) as follows:

"The complex consists of sovite, silicocarbonatite, ijolite, rauhuagite and various dike rocks. The carbonatite intrusion is zoned from a calcite border to a ferruginous dolomite core. The rocks of the complex have yielded dates by K-Ar isotopic techniques of 1008 and 1087 Ma. (Gittins et al. 1967)."

The reader should refer to Sage (1983a) for a discussion of the Firesand River Carbonatite.

PROTEROZOIC

DIABASE DIKES AND LAMPROPHYRES (MAP UNIT 12)

DIABASE DIKES

Diabase dikes are common to the area and previous mappers as well as the author have considered them to be Keweenawan in age. Some exceed 30 m in width and all display steeply dipping vertical to subvertical straight contacts. The dikes extend across the map area but may be subjected to pinching and swelling over short distances. The dikes may also display *en echelon* emplacement along strike. The diabase dikes have little if any economic significance and their importance is of a structural nature. The dikes commonly occupy shear zones or faults and mapping and location of the dikes is important in unraveling the structure. Most faults are in reality fault zones defined by several very closely spaced faults. Consequently, the fault zones may be filled by several parallel closely spaced diabase dikes. The bulk of the diabase is a typical medium-grained, equigranular, massive diabase that weathers to form high, sometimes ridge-like, outcrops.

One relatively uncommon variety weathers brown and is somewhat crumbly and is interpreted to be an olivine diabase.

One variety of diabase has large green plagioclase crystals which occur both as single crystals and as clusters of crystals. Crystals may be up to 5 to 6 cm and such dikes are very distinctive in the field. Plagioclase-phyric dikes have been traced along strike into plagioclase-free diabase indicating the presence or absence of phenocrysts cannot be used to identify a particular dike or dike set.

All dikes display chilled margins and the host rocks are hornfelsed along the contact. There are varying degrees of development of these features from dike to dike. The larger dikes generally have wider zones of hornfels and these wider dikes also display the greatest variation in grain size. The larger dikes can display good medium-grained gabbroic centres which may contrast sharply in appearance with the very fine-grained chilled margins. The hornfels margins on some of the larger dikes may equal or approach the width of the dike suggesting that magma flowed through the dike to provide sufficient heat to develop such wide contact aureoles. The contact aureoles are best developed in greenschist rank rocks where devolatilization occurred creating a hard flinty hornfels that contrasts sharply with the soft carbonate-chlorite-sericite rich greenschist rank rocks. Baked intermediate to mafic metavolcanic rocks develop a hard cherty subconchoidal fracture which can easily result in the rock being falsely classified as felsic.

The presence of the hornfelsed contacts can aid mapping in areas where the diabase may or may not be exposed. Noting hornfelsed and non-hornfelsed outcrops permits tracing

of diabase dikes through areas lacking exposure of the dike. The recognition of hornfelsed rock, when working along steep hills or rock faces, should warn the mapper to check the back side of the outcrop for the presence of a diabase dike.

The dikes display two prominent trends. The northwest trend is by far the dominant in the present map area and these dikes strike at approximately 330 to 340°. A subordinate set of dikes trends at roughly 40 to 50° and does not display a easily recognizable close association with faulting and shearing. At the Helen Iron Range, Moore and Armstrong (1946, p.101) reported that the northeast-trending dikes cut the northwest-trending dikes. The author concurs with Moore and Armstrong (1946), however, the crosscutting relations are not as clear cut as one would hope. At some positions along the diabase-diabase contact, a clearly defined contact relation could not be observed. All textural and compositional varieties of dikes occur in both sets. The dikes appear to be a conjugate set and the author anticipates essentially contemporaneous emplacement of both northwest and northeast-trending dikes. Moore and Armstrong (1946, p.102) reached similar conclusions. They consider the quartz-bearing diabase to be the youngest and all dikes represent essentially one period of igneous activity with quartz-free diabase being emplaced first and quartz-bearing emplaced last. Moore (1931, p.12) previously considered the olivine diabase younger than the quartz diabase.

Diabase dikes near Parks Lake, Corbiere Township, north and adjacent to the map area have been offset by strike slip faulting and brecciated. Both brecciated and altered diabase have been noted in several areas so, there is post-diabase movement in the region. Collins and Quirke (1926 p.38) observed brecciated diabase northwest of Loonskin Lake which they attributed to post-dike movement.

Since the diabase dikes are of little direct economic interest the author has not prepared thin sections from them. Extensive literature exists on these dikes and will be summarized.

While the early investigators have lumped older later and earlier dike-like and sill-like mafic intrusive rocks into one group, Matheson (1932, p.9, 1933) and Froberg (1935) subdivided the later mafic dikes into three groups; normal diabase, quartz diabase and olivine diabase. Matheson (1932, 1933) gives the most complete subdivision of the diabase dikes. He considers the olivine diabase as younger than the quartz diabase as did Moore (1931). Matheson (1932, p.10, 1933, p.58) indicates all olivine diabase as porphyritic, however, dikes classified in the field as olivine diabase by the author were nearly all non-porphyritic. The area studied by Matheson (1932, 1933) lies south and west of Wawa and outside the author's area of investigation. Massey (1985) who recently mapped the area covered by Matheson did

not subdivide the diabase dikes. From his description the dikes would fall into both the normal and quartz diabase classes of Matheson (1932, 1933).

NORMAL DIABASE

Matheson (1932, p.57, 1933, p.10) described the normal diabase as occurring only in narrow dikes. The rock is described as having 30 to 40% plagioclase, 55 to 65% pyroxene and 2.5 to 10% iron-titanium oxide. The dike is similar to the quartz diabase but lacks quartz (Matheson 1932, p.57, 1933, p.10). Frohberg (1935, p. 46) reported accessory apatite.

QUARTZ DIABASE

Quartz diabase is the most common diabase in the area (Frohberg 1935, p.46). The dikes weather green and may be speckled with white weathering plagioclase that may be as large as 15 cm (Matheson 1932, p.55; 1933, p.10). The phenocrysts may be unevenly distributed, display rounded edges and do not occur at the immediate contact of the dike. In some dikes the phenocrysts weather high, in other dikes low. The dikes have a diabasic texture and are estimated to contain 40 to 50% plagioclase, 40 to 50% clinopyroxene, 4 to 7% iron-titanium oxide and 2 to 4% quartz (Matheson 1932, p.56, 1933, p.10). There are trace to minor amounts of apatite, uraltite, chlorite, biotite, leucoxene, sericite and pyrite. Massey (1985, p.41) reported that hypersthene can be present and that trace amounts of epidote, sphene and albite may be present in the groundmass.

The plagioclase is reported as andesine to labradorite in composition, the pyroxene is augite, diopside, or diopside and enclosed in fresh hornblende, (Matheson 1932, p.56, 1933, p.10). Matheson (1932, p.57) reported that the iron-titanium oxides are skeletal and may display reaction rims of biotite and fibrous green amphibole at the contact with plagioclase.

Interstitial granophyric intergrowths of quartz plus plagioclase is present which are composed of 43% quartz and 57% plagioclase (Matheson 1932, p.57, 1933, p.10). Matheson (1932, p.57) reported the plagioclase intergrowth to be andesine to oligoclase in composition. Massey (1985, p.40) reported the presence of an ophitic texture in the centre of some dikes.

OLIVINE DIABASE

The olivine diabase dikes are described as uncommon and all as porphyritic (Matheson 1932, p.58, 1933, p.10). Tabular plagioclase crystals up to 7.5 cm are in sharp contact with the fine-grained groundmass. The olivine diabase is generally fresher than the

quartz diabase in thin section. The dikes have a good diabasic texture and are estimated to average 57% plagioclase, 24% augite, 13% iron-titanium oxide and 1% fayalitic olivine (Matheson 1932, p.58, 1933, p.11). Biotite, uraltite and chlorite form approximately 4% of the rock and traces of quartz may be present. The plagioclase of the groundmass is of andesine composition and much more altered than the phenocrysts which average An₅₀ (Matheson 1932, p.58, 1933, p.11). At the outer edge of the phenocrysts, inclusions of augite, olivine and needle-like opaque oxide crystals are present. The phenocrysts display albite and pericline twinning and borders of some crystals are intergrown with more sodic plagioclase at right angles to the crystal boundary (Matheson 1932, p.59, 1933, p.11).

Matheson (1932, p.59) described the pyroxene as fresh augite of a pale green colour and the fayalite as brown in colour with extensive alteration along cracks to hematite plus magnetite. He also reported that the olivine has an abundance of oriented inclusions. Ilmenite, augite and fayalite are subrounded with a pale green micaceous mineral, possibly biotite (Matheson 1932, p.59). Traces of interstitial quartz may be present.

Most of the dikes mapped as olivine diabase by the author were non-porphyrific and weathered rusty brown. Some of the outcrops of olivine diabase were deeply weathered, crumbled readily and were difficult to sample.

In McMurray Township, several fine-grained, red, syenite dikes less than 0.3 m wide were encountered. These syenite dikes are likely related to the alkalic intrusive event that occurs northeast of Wawa along the Kapuskasing Structural Zone (Gittins et al. 1967). These rare dikes were not examined in thin section. Massey (1985) described a microsyenite dike south of the Michipicoten River that is 4 m wide. He describes the dike as very fine-grained with subhedral microphenocrysts of pink potassium feldspar. The groundmass was described as iron stained orthoclase with minor quartz, sodic amphibole and Fe-Ti oxides (Massey 1985). Massey (1985, p.43) reported that the syenite dike cut lamprophyre dikes.

LAMPROPHYRES

Lamprophyres are common in the area south of Wawa Lake. The author has not studied these dikes in detail and has relied on previous descriptions.

On old mine plans and on the many waste dumps of former gold mining operations south of Wawa lamprophyre dikes are indicated to be common. The dikes are often carbonate-bearing and weather subdued and are generally not encountered in outcrop. Lamprophyric dike material on waste dumps at old gold mines is deeply weathered, commonly crumbles and is unsuitable for study. When available to observation the dikes walls often display a ribbed weathered surface with the ribs parallel to the wall contacts. The

ribbing implies that some dikes represent multiple intrusions of magma of similar composition.

The author has observed fresh lamprophyre only in road cuts along Highway 101 in the migmatitic terrain south of the turn-off to Hawk Junction, where numerous narrow dikes are present. On the basis of old reports, mine plans and surface maps examined by the author lamprophyre dikes are most common in the area south of Wawa Lake, but they appear to be rare or uncommon north of the lake. Frohberg (1935, p.46) and Gledhill (1927, p.16) made similar observations. The lamprophyres have been related to phases of diorite or granite intrusion (Gledhill 1927, p.14; Moore 1931, p.12; Matheson 1933, p.12, Frohberg 1935, p.48), however, the author considers them to be much younger than the granitic rocks and most likely related to the emplacement of the Firesand River Carbonatite. This carbonatite has been dated by K-Ar isotopic techniques as being 1008 and 1087 Ma (Gittins et al. 1967). Narrow lamprophyre dikes encountered in diamond drilling by Dunraine Mines Limited are bordered by blue-tinted rock. X-ray diffraction studies of this blue-tinted rock indicated the presence of a fine-grained alkali amphibole. The author considers the development of the alkali amphibole analogous to fenite alteration. Fenitization or alkali element-iron metasomatism is characteristic of carbonatite intrusions and the Firesand River Carbonatite has a fenite halo approaching 1.6 km in width (Sage 1983a). Frohberg (1935, p.47) recognized the blue fibrous amphibole in association with lamprophyre and reported the presence of rutile along with the blue fibres. Frohberg (1935, p.47) identified the blue amphibole as riebeckite. Dikes related to the carbonatite intrusion would be expected to display a fenitic metasomatism effect similar to the carbonatite but on a much smaller scale.

The lamprophyre dikes are narrow, generally less than 1 m in width and only rarely approach 2 m in width. They strike northeast and dip vertically to subvertically. Frohberg (1935, p.46) reported a similar strike and dip. This trend is subparallel to the Wawa Lake Fault which is subparallel to fault trends associated with the Kapuskasing Structural Zone. In the area south of Wawa Lake, Frohberg (1935, p.46) indicated lamprophyres are more common than diabase and Matheson (1932, p.61) reported that the lamprophyre dikes are porphyritic (plagioclase and olivine?) and commonly banded in appearance. The lamprophyres cut diabase dikes (Frohberg 1935, p.45). The author correlates the Firesand River Carbonatite with the lamprophyres. The carbonatite also cuts a diabase dike (Sage 1983a). The Firesand River Carbonatite and lamprophyres appear to be the youngest intrusive rocks in the Wawa area. Frohberg (1935, p.46) reported that lamprophyres are not associated with faulting.

Frohberg (1935, p.47) observed that the lamprophyres have bleached margins as a result of hydrothermal alteration and that wall rock xenoliths occur in some dikes. Frohberg (1935, p.47, 48) reported that pyrite, marcasite and chalcopyrite may occur in the walls next to the dikes. Gledhill (1927, p.17) reported that some lamprophyres resemble kimberlite. The author has observed weathered lamprophyre that resembles kimberlite but detailed mineralogical studies will be required to establish a kimberlite identity for any of the dikes.

Previous workers have subdivided the lamprophyres into two varieties; olivine-rich and biotite-rich dikes (Gledhill 1927, p.14; Matheson 1933, p.12; Frohberg 1935, p.46). Frohberg (1935, p.46) reported that the biotite-rich variety cut the olivine-bearing variety and he classifies the older dikes as kersantite. Gledhill (1927, p.16) classified the olivine-bearing dikes as picrite lamprophyres.

The olivine lamprophyres contain rounded to subhedral grains of olivine altered to serpentine and carbonate which give the dike a spotted appearance, Gledhill (1927, p.14, 15). Frohberg (1935, p.47) reported that in addition to olivine and its alteration products the dikes contain biotite, augite, apatite, chlorite and iron-titanium oxides. He also reported that the various minerals vary considerably in relative quantities from dike to dike. Frohberg (1935, p.47) observed that carbonate is common in the dikes and that serpentine and chlorite is the alteration product of olivine, augite and biotite.

The author has observed altered olivine exceeding 50% of the lamprophyre dike and Moore (1931, p.12) reported that olivine may form up to 65% of the dike.

The mica dikes may contain 20 to 30% carbonate, (Gledhill 1927, p.15). Frohberg (1935, p.48) reported that these mica-bearing dikes contain biotite, andesine, minor orthoclase and secondary chlorite and carbonate.

Mitchell and Janse (1982) have reported an ocellar monchiquite lamprophyre dike south of Wawa that contains xenoliths of harzburgite and wehrlite. The dikes contain xenocrysts of olivine in a panidiomorphic groundmass of titanomagnetite, aluminous pyroxene, titanian phlogopite, with a mesostasis of analcite, iron-rich pyroxene and calcite. They interpreted the xenoliths to be depleted mantle material derived from depths of 50 to 90 km.

Along Highway 101 in numerous road cuts, narrow, vertical to subvertical dipping, rusty weathering, carbonate-rich, radioactive dikes are present. These dikes rarely exceed 10 cm in width, but locally may approach 25 cm in width. The dikes may be braided and biotite and Fe-Ti oxides are the only easily recognizable minerals in hand specimen. Their radioactivity is dominantly due to potassium with minor uranium and thorium. Table 6 is a tabulation of data taken on these dikes along with assay results. Figure 58 is a sketch map showing the location of these dikes. The dikes weather easy and are not likely to be of

commercial value. The dikes display a crude orientation radiating out from the Firesand River Carbonatite and are likely closely related to this intrusion.

PHANEROZOIC

CENOZOIC

PLEISTOCENE AND RECENT

The Archean and Proterozoic rocks of the Wawa area are locally extensively covered by Pleistocene and Recent deposits. The Recent deposits consist largely of reworked Pleistocene glacial deposits with minor accumulations of organic material. Collins and Quirke (1926) prepared a brief account of the surficial deposits of the area. At the time of the work by Collins and Quirke (1926, p.44) the forest cover had locally been removed by fire in some areas and in the project area the treeless area north of Wawa offers a unique opportunity to examine surficial deposits along the Magpie River in Chabanel Township.

Collins and Quirke (1926, p.46) attributed terraces below 656 feet elevation as belonging to the Nipissing stage of the Great Lakes and the higher terraces to the older Lake Algonquin. A total of 7 terraces at 633.5, 656.0, 724.0, 742.0, 840.0, approximately 1,000.0 and at approximately 1085.0 feet elevation were recognized by Collins and Quirke (1927, p.45). The town of Wawa lies on Collins and Quirke's (1926, p.45) terrace no.6 and the terraces were interpreted by them to be cut terraces resulting from the lowering of the level of Lake Superior and not built terraces. The recent deposits are formed entirely from reworked older Pleistocene glacial deposits (Collins and Quirke 1926, p.44).

Between Mission on Lake Superior and Wawa, Coleman (1922, p.25, 26) reported the presence of 10 beach ridges between 623 and 810 feet elevation. Wawa was measured by him (Coleman 1922, p.26) as being at an elevation of 960 feet and other beach levels were noted at the elevations of 1,042; 1,088 and 1,140 feet. Beach levels below 700 feet were attributed to glacial lake Nipissing and those above 700 feet to glacial lake Algonquin (Coleman 1922, p.25).

Recent work by Frey (1986, 1987) classified the Pleistocene and Recent deposits as tills, ice contact, outwash, and post glacial organic deposits.

Frey (1986, 1987) reported the presence of isolated pockets of grey sandy till with a calcareous matrix on walls of northeast striking lineaments and he reported the presence in a hillside excavation on the south shore of Hawk Lake of a clast-rich, poorly sorted, weakly consolidated gravel with a calcareous silt and sand matrix. The clasts in the hillside excavation are angular to subrounded and Frey (1986, p.4) interpreted this deposit as a recessional deposit, possibly a melt-out till or debris flow from a stagnating ice mass.

The extensive flat area of Jack pine cover between Hawk and Wawa Lake is part of a meltwater spillway into the Lake Superior drainage basin and is characterized by well rounded cobbles as a surface lag deposit, kettle lakes and depressions (Frey 1986, 1987). The force of the water discharge is exemplified by a large pothole 2 m in diameter and greater than 3 m deep eroded into intermediate to mafic metavolcanic rocks at the east end of Wawa Lake exposed during construction of Highway 101. Collins and Quirke (1926, p.48) previously recognized the possibility of a river outlet between Hawk and Wawa lakes through the prominent narrow gap between the two lakes, but the well developed potholes were not recognized until exposed by highway construction.

At the east end of Wawa Lake, a gravel pit exposes well developed deltaic sediments formed during meltwater runoff through the narrow gap between Wawa and Hawk lakes (Frey 1986, 1987). The gravels display steeply dipping foreset beds of poorly sorted weakly calcite and iron oxide cemented gravel and coarse sand (Frey 1986, 1987). Topset beds characteristic of deltaic stratigraphy are absent (Frey 1986, 1987).

Collins and Quirke (1926, p.46) equated the broad flat areas around Hawk Junction as part of their terrace 7 or their highest terrace level.

At the Wawa townsite, Frey (1986, 1987) described the terrace on which the town is built as a barrier beach bar composed of sand and gravel that sealed the southern entrance of the Wawa Lake basin when the lake was a bay in post-Minong times. Shoreline wave cutting and fluvial terrace development has modified the barrier beach (Frey 1987, 1987). The western half of the town sits on a prominent terrace or beach surface and three steep escarpments are traceable across town (Frey 1986, 1987). Frey (1986, 1987) reported that from the upper to the lowest that the scarps are 3, 7.4 and 30 m in height. The barrier bar is being incised at its south end by Wawa Lake outflow along Wawa Creek (Frey 1986, 1987). Coleman (1922, p.26) interpreted the terrace at Wawa to be a bar that dammed a bay of the former lake Algonquin.

As a result of fire and atmospheric fallout of sulphur dioxide, the treeless area along the Magpie River north of Wawa offers an exceptional exposure of river terraces.

Frey (1986, 1987) recognized 6 paired terraces along the Magpie River with a total vertical relief greater than 60 m. The terraces are composed of glaciofluvial, glaciolacustrine material which is being incised by the Magpie River in the treeless area (Frey 1986, p.6). The escarpments face downstream and Frey (1986, 1987) suggested the highest surface may represent a Minong shoreline. The characteristic of these terraces is a lag concentrate of rounded cobbles and boulders from 0.5 to 3 m thick (Frey 1986, 1987). Gully formation by headward erosion and subsurface springs contribute to slope failure (Frey 1986, 1987).

Collins and Quirke (1926, p.48) referred to this boulder capped terrace along the Magpie River as their seventh terrace and interpret it to represent proximity to an ancient shore and the upper limit of submergence. The finer sand and silt was removed from between the boulders by the receding lake water creating the cobble and boulder lag deposits (Collins and Quirke 1928, p.48). Since the vegetation has been removed from this terrace, winds have winnowed the terrace surface creating ablation sand dunes on the north central part of the terrace where bed rock pokes up through the terrace and ablation sand deposits.

The stratigraphy of the Magpie River terraces from bottom to top, is 3 m or more of varved clay-silt, 13 m or more of thinly bedded silty sand containing clay granules toward the base and with coarsening upward bedding units of 19 to 25 cm width, and in excess of 3 m of sandy gravel to cobbles at the top (Frey 1986, 1987).

Inland from the terraces crescentic and linear end moraines and numerous large isolated erratics overlie the glacially moulded bedrock surface (Frey 1986, 1987). During mapping, nepheline syenite boulders from the Herman Lake Alkaline Rock complex were encountered as far south as the Lucy Iron Range, a distance of approximately 30 km from their source.

The moraines are small, dispersed, up to 500 m long and 20 m in relief (Frey 1986, 1987). Frey (1986, 1987) interpreted the subdued moraines with small areas of accompanying kame and kettle topography to suggest rapid glacial recession.

In the bottoms of some linear valleys, members of the field party have locally encountered floors paved with angular to rounded boulders from which the fines have been largely removed. These boulder floors are interpreted to result from the winnowing of the fines from between the boulders during melt water run off during glacial retreat.

The surficial geology of the area has been examined regionally using air photographs and interpreted by Gartner and McQuay (1979) and McQuay (1980).

METAMORPHISM AND ALTERATION

The Wawa supracrustal sequence is, in some ways, a typical Archean greenstone belt. The belt displays upper greenschist to amphibolitic margins and a greenschist core typical of telescoped metamorphic aureoles that enclose Archean supracrustal sequences. The higher metamorphic grade margins contain much less carbonate than the core of the belt and are represented by amphibolitic rocks in which the amphibole is altered to chlorite suggesting that the amphibolitic rocks marginal to the belt have been retrograded to greenschist facies in a later regional metamorphic event.

The higher grade greenstone belt margins are the result of contact metamorphism resulting from emplacement of the younger granitic masses along the margins of the greenstone belt which preceded retrograde metamorphism in response to regional metamorphism. This conclusion is in agreement with Ayres (1978) who investigated the metamorphism of the supracrustal rocks in this region east of Lake Superior.

The rocks marginal to and included within, the Jubilee Stock are massive and lack good secondary structures even though visually the mineral assemblage is of greenschist rank. The Jubilee Stock undoubtedly had a thermal aureole but it has been retrograded to greenschist facies. Collins and Quirke (1926, p.126) reported little evidence for a thermal aureole around the Jubilee Stock and Massey (1985, p.48) reported a lack of contact metamorphic effects around felsic stocks examined by him in the adjoining area to the south. Collins and Quirke (1926, p.129) reported that the Gutcher Lake Stock in Abotossaway Township displays little evidence of thermal metamorphism. Studemeister (1982), however, reported that the Gutcher Lake Stock has a contact thermal aureole up to 1 km in width which subsequently underwent retrograde metamorphism in a regional greenschist rank metamorphic event. This contact metamorphic aureole is of the epidote-hornblende hornfels rank and reached a maximum temperature of 500°C during development (Studemeister 1982, p.229, 242). The presence of a thermal aureole around the Gutcher Lake Stock has been confirmed by the author. Undoubtedly, other granitic stocks that intrude the supracrustal rocks have contact aureoles but retrograde metamorphism during a regional metamorphic event makes their recognition and delineation sometimes difficult.

The Jubilee Tuffs are characterized by the presence of biotite flakes both individually and as elliptical clots and have the appearance of being of higher metamorphic rank than other rocks found in the immediate area. Much more detailed mapping by Studemeister (1984, personal communication) for Dunraine Mines Limited in proximity to the former Darwin Property, suggests that the biotite-bearing rocks terminate to the west at the Darwin shear zone and this shear zone marks a transition between lower (west side) and upper (east

side) greenschist rank metamorphism. This transition is also observed further north at the Jubilee Shear Zone where rocks east of the shear zone are of slightly higher rank than those west of the shear zone. Rocks in proximity to the Firesand River Carbonatite and south to Reed Lake are lower greenschist facies. The location of the transition zone from upper greenschist rank to low greenschist rank as one moves east from the Darwin and Jubilee shear zones is obscure and is probably gradational. The fact that the Jubilee Tuffs commonly exhibit upper greenschist rank mineralogy and that they are restricted in areal distribution to the proximity of the Jubilee Stock suggests that they represent contact metamorphism resulting from emplacement of the stock.

Studemeister (1985b, p.83) described the mineralogy of the granitic rocks of the Jubilee Stock as plagioclase of oligoclase composition, quartz, biotite, white mica and epidote. Studemeister (1985b, p.83) described the plagioclase as being rimmed with albite and undergoing alteration to quartz, white mica, calcite and epidote. The amphibole and epidote were mottled with chlorite, calcite and quartz (Studemeister 1985b, p.83). Studemeister (1985b, p.83) reported that the greenschist facies assemblage is more prevalent near shear zones than in the more massive rocks of the stock.

The mineralogy of the hornfelsed rocks of the aureole is sodic plagioclase, epidote, quartz, biotite and minor amphibole (Studemeister 1985b, p.83). Studemeister (1985b, p.83, 85) also reported the presence of traces to minor andalusite, pyrite, pyrrhotite, chalcopryrite and native gold.

The amphibole displays incipient alteration to chlorite, white mica and calcite and the epidote has iron rich cores (Studemeister 1985b p.83, 85). The epidote displays mottled alteration by chlorite and calcite.

Studemeister (1985b, p.85) interpreted the Jubilee and Gutscher Lake stocks to indicate that intrusion and metamorphic aureole development preceded regional metamorphism. The regional metamorphic event involved the influx of fluids containing H_2O plus CO_2 of metamorphic origin (Studemeister 1985b, p.87). These metamorphically derived fluids reacted with the mineralogy of the stock and contact metamorphic aureole forming hydrous silicate minerals, fixed carbon dioxide, leached strontium and reduced the iron (Studemeister 1985b, p.87).

The rocks south of Wawa Lake do not display the same pervasive regional carbonate alteration as rocks north of Wawa Lake. South of Wawa Lake, carbonate alteration is more extensive in the lower greenschist facies than in the upper greenschist facies rocks. South of Wawa Lake, the most intense carbonate alteration occurs in association with faults, shear zones, fractures and quartz veins. This relationship indicates structural or lithologic control which is absent in the regional carbonatization event north of Wawa Lake.

South of McMurray Township, Massey (1985, p.48) reported that the supracrustal rocks vary from low greenschist rank to upper greenschist rank. He interpreted the presence of grunerite in the iron formations of the area to indicate conditions of 350°C and a pressure of 200 MPa. He also observed the telescoped nature of regional metamorphism which is represented by greenschist rank rocks within the core of the supracrustal rocks and amphibolite rank rocks along the margins next to the granitic terrain.

North of Wawa Lake, carbonate alteration is extensive and is regional in extent. The rocks examined by the author in Chabanel Township, the northwestern half of Esquega Township, the southeastern third of Musquash Township, the southeastern corner of Leclaire Township and throughout Abotossaway Township are pervasively soaked with carbonate. This regional carbonate alteration lacks structural or lithologic control and where very intense, the separation of rocks originally felsic in composition from those originally mafic in composition is difficult if not impossible. During mapping, the author has placed a much greater reliance on primary rock textures than colour as an indicator of former rock composition. Mafic rocks pervasively soaked with carbonate weather much lighter shades of green than rocks with little carbonate and where alteration has been extensive, the brown, yellow-brown weathering of mafic rocks is indistinguishable from weathering of pervasively carbonated felsic metavolcanic rocks.

Within the wacks above the Lucy Iron Range, weathered surfaces indicate the presence of 10 to 20% porphyroblastic rhombohedral orange brown carbonate. Mafic intrusions, particularly narrow dikes and narrow apophyses branching off from larger intrusions, may be replaced by up to 40% brown, rhombohedral, orange brown carbonate in crystals up to 3 mm. These crosscutting dikes are now largely composed of carbonate and chlorite and their primary composition uncertain but thought to range from ultramafic to quartz diorite.

The presence of pervasive and intense carbonate alteration in rocks of cycle two above the Michipicoten Iron Formation indicates that the regional carbonatization occurred after this volcanism and that it is unrelated to iron formation deposition or to any specific volcanic cycle. Carbonate alteration associated with iron formation deposition has been masked or even obliterated by this regional carbonatization event preventing clear delineation of carbonate alteration zones associated with iron formation deposition. It has been suggested that this regional carbonatization event may have occurred contemporaneous with folding (Young 1953, p.90). Young (1953, p.100, 101) was the first investigator to separate siderite carbonate alteration related to iron formation deposition from ankeritic carbonate that characterizes the regional carbonatization event. The author, Richter (1952, p.77) and Young (1953, p.101) considered the regional carbonatization event to be one of ankeritization.

Undoubtedly, the failure of early investigators to recognize these two carbonate alteration events resulted in the interpretation that the lower contact of the iron formation was gradational into the underlying carbonate-rich metavolcanic rocks and that the siderite and pyrite are replacement rather than primary sedimentary deposits. The recognition of at least two carbonate alteration events is important for it cautions against the use of present rock carbonate content to model, outline and define carbonate alteration halos associated with iron formation deposition. Bulk carbonate content is a sum total of carbonate alteration associated with iron formation deposition and carbonate flooding by a regional metasomatic-metamorphic event. In general, the rocks stratigraphically below the iron formation are the most carbonated however similar extensive carbonate alteration was observed in the mafic metavolcanic rocks immediately overlying the Lucy and Rand No.2 (Abotossaway Township, outside the map area) iron ranges. At the Lucy and Josephine iron ranges, the top of the mafic section of cycle one volcanism lying stratigraphically below the felsic metavolcanic rocks of cycle one volcanism is also extensively carbonatized.

In addition to a general evenly distributed regional soaking of carbonate, carbonate also occurs as orange brown weathering carbonate-filled fractures, irregular vein-like masses, interclast fillings in breccias, interpillow fillings in flows and fillings in primary cavities such as amygdules. The larger fracture fillings commonly display thin, irregular stringers of white milky quartz on the weathered surface.

Richter (1952, p.78) recognized that the schistosity in the footwall rocks of the iron formation bends around knots of siderite at the lower contact. Richter (1952, p.78) observed that the ankerite is evenly distributed throughout the footwall rocks and if present as distinct masses it crosscuts stratigraphy. Richter (1952, p.78) concluded that the original composition of the rocks did not influence the character of ankerite carbonatization as would be expected if there was a relationship with iron formation. Richter (1952, p.79) observed that the rocks associated with iron formation are highly sericitized, however, he also observed that many rock types are sericitized in the Wawa area and it cannot be determined with certainty whether sericitization is a product of alteration associated with iron formation deposition or regional metamorphism. The author considers sericite to be a product of regional metamorphism of rocks of appropriate composition, some of which may have obtained the appropriate composition by way of hydrothermal alteration prior to regional metamorphism.

The unusually high carbonate content combined with such broad regional distribution presents a problem of source for so much carbon dioxide. The only other area where such pervasive carbonate alteration has been observed by the author is on the Slate Islands in northeastern Lake Superior (Sage 1983b).

Upon mapping and observing widespread regional carbonatization the author initially suspected that the mantle had to be involved as a source for so much carbon dioxide by some unknown and yet to be defined process. Mapping has disclosed, however, that not only is extensive carbonate present in the Michipicoten Iron Formation but carbonate also occurs as a ferruginous dolomite unit in the stratigraphic section below the iron formation. This unit is 30 m thick on the Ruth Iron Range and exceeds 60 m in thickness at the east end of the Josephine-Bartlett Iron Range, Corbiere Township (outside the map area).

The first cycle volcanism up to and including the iron formation contains two carbonate-bearing rocks of considerable thickness. The supracrustal rocks have been metamorphosed to amphibolite rank of regional metamorphism along the flanks of the belt and presumably the keel of the supracrustal rocks reached similar grades. Turner (1968, p.366) suggested that amphibolite rank represents a temperature range of approximately 450 to 650°C depending on pH_2O and depth of burial. Since the rocks were deposited subaqueously and were porous one can assume that sufficient water was available for any needed reactions. The depth of burial at the time of carbonatization is unknown, however, the present level of exposure was not likely deeply buried. Devolatilization or metamorphic degassing of carbon dioxide occurs between 375°C and 575°C (Ferry 1983, p.336) and thus, the carbonate bearing-stratigraphy of first cycle volcanism when subjected to metamorphic conditions suitable for devolatilization along the margins and keel of the supracrustal sequence may have provided the required CO_2 . Tentatively, the author proposes that the pervasive soaking by carbonate of the low grade greenschist facies supracrustal rocks central to the Wawa greenstone belt is the result of metamorphic degassing at structurally lower levels within the supracrustal sequence at conditions of amphibolite-rank regional metamorphism. The resulting metamorphic devolatilization drove the volatiles upward causing the pervasive regional soaking by carbonate. The unusually extensive soaking of carbonate in the Wawa belt compared to other greenstone belts is a function of the unusually well-developed carbonate-bearing units within the stratigraphy of first cycle volcanism that provided a source for the carbon dioxide. Carbonate rocks appear to be restricted to first cycle metavolcanic rocks and do not appear in either older or younger cycles. At deep levels within the supracrustal rocks, one would expect to encounter the development of an iron-rich calc-silicate mineral assemblage in response to metamorphism and devolatilization of the Michipicoten Iron Formation and stratigraphically lower ferruginous dolomite. LeSeellur (1980, p.59, 61, 72, 74) has suggested that the fluid depositing the iron formation was Archean seawater with a significant contribution from metamorphic outgassing of CO_2 . A pre-cycle one stratigraphy, rich in carbon dioxide bearing minerals, is not now exposed or preserved within the Wawa supracrustal rocks. The author suggests that the regional

carbonatization event represents a metamorphic outgassing event of the carbonate-rich stratigraphy represented in cycle one. The timing of this metamorphic event is uncertain but it is likely to be either syndeformation or immediately post-folding and related to the structural evolution of the Wawa supracrustal sequence. Since it effects all cycles of volcanism, it is post-volcanic. The metamorphic fluid outgassing associated with iron formation deposition must be a much earlier post-volcanic cycle one event that preceded cycle two volcanism (LeSeelleur 1980).

The late quartz + carbonate + pyrite + arsenopyrite veins cutting siderite at the Lucy Pit display contact metamorphism. The siderite, arsenopyrite and pyrite become coarsely crystalline next to the quartz veins. This feature has been described under, "Iron Formation Late Quartz Veins" in this report.

Diabase dikes cut the region and where they cut and come in contact with siderite, devolatilization of the siderite has taken place and magnetite formed. Magnetite was formed in the siderite at the Ruth Iron Range marginal to a 50 m wide diabase dike for a distance of approximately 17 m (Richter 1952, p.79) and (Canadian Mining Journal 1956, p.83) reported magnetite-bearing contact hornfelsed zones from 1.6 to 8.3 m in width marginal to diabase dikes cutting the Helen Iron Range. Richter (1952, p.81) reported lath-shaped amphibole crystals, possibly grunerite, in association with magnetite in a unspecified altered zone at the Helen Iron Range. This alteration zone was probably a thermal aureole to a diabase dike.

Diabase dikes invariably display a thermal contact aureole with the enclosing supracrustal rocks. This thermal aureole is most apparent in the greenschist facies carbonate-rich rocks. The carbonate-rich rocks in contact with the diabase have been devolatilized and the rock changed to a fine-grained, hard, cherty hornfels. Marginal to the larger diabase dikes the thermal contact zone may visually extend up to 60 m from the actual contact. In general, most dikes are 30 m or less and their thermal aureole is correspondingly narrower in width. The width of some thermal aureoles appear to be out of proportion with dike width suggesting that the dike was a conduit for heat addition to the supracrustal rocks.

The hard cherty hornfels gives the impression of being felsic even though it may really be mafic in composition. Rock hardness is no indication of rock composition along dike margins but a measure of volatile depletion. The larger dikes with good thermal aureoles are easily traceable where unexposed if the mapper notes whether the outcrop has been hornfelsed or not. Tracing of dikes is more difficult in the granitic and amphibolitic terrains where the volatile content of the wall rocks is low and a easily recognizable contact aureole fails to develop.

A magnetite-bearing contact zone between Archean mafic intrusions and the carbonate facies of the Helen Iron Range has been reported (Canadian Mining Journal 1956, p.85) but not confirmed in mapping by the author.

The Helen Iron Range and presumably the other iron ranges, contain chamosite ($\text{Fe}_2\text{MgFe}_3\text{Al}(\text{Si}_3\text{Al})\text{O}_{10}(\text{OH})_8$) and sauconite ($\text{Na}_{0.3}\text{Zn}_3(\text{SiAl})_4\text{O}_{10}(\text{OH})_2\cdot 4\text{H}_2\text{O}$) indicating a low rank grade of regional metamorphism (Karkhanis 1978, p.432; Fleischer 1987). The presence of grunerite in the iron formations south of Wawa (Massey 1985, p.48) indicated that the iron formations in the supracrustal rocks south of Wawa are of higher metamorphic rank than those within the immediate vicinity of Wawa.

The reader should refer to Sage (1983a) for a description of the alteration and metasomatism associated with the Firesand River Carbonatite which straddles the McMurray-Lastheels Township boundary. A fenitic halo representing Na, Fe and CO_2 metasomatism up to 1.6 km in width encloses this carbonatite and has been superimposed on rocks of greenschist facies rank (Sage 1983a).

Mapping within the four townships covered by this report has outlined numerous areas of chloritoid alteration which may or may not be associated with iron formation. The following observations were made:

1. Rocks containing chloritoid are pervasively carbonatized but pervasive carbonate alteration does not necessarily mean that chloritoid is present.
2. The widespread occurrence of chloritoid suggests that the alteration that resulted in a rock composition favourable for the development of chloritoid was likely part of the original volcanic process.
3. The wide distribution of chloritoid indicates that the alteration process must represent a simple rather than complex system. The process has occurred more than once being present in volcanic cycles one and two but its greatest development is in the upper part of first cycle volcanism extending upward into the bottom part of second cycle volcanism.
4. Chloritoid occurs in approximately equal amounts in both intermediate to felsic and intermediate to mafic metavolcanic rocks and only in minor amounts in mafic intrusions. It has been identified in only one outcrop of metasedimentary rock.
5. The process that brought about the alteration of the original volcanic rocks is one of homogenization; felsic and mafic rocks have been altered to a similar-appearing carbonate-chloritoid rock whose original composition is difficult to determine.
6. The chloritoid crystals display a random orientation, implying that they formed post-tectonically in response to a regional metamorphic event in altered rocks of appropriate composition.

7. In some fragmental units, the chloritoid shows a preferential development in the clasts over the matrix; in other outcrops, the opposite is true (Plate 35). Fracture-controlled (possibly cooling cracks) chloritoid development has been observed in rare instances (Plate 36). In the pillowed to massive units, chloritoid commonly preferentially occurs in the pillow selvages, although outcrops displaying equal distribution of chloritoid throughout the pillow structures are not uncommon. Chloritoid distribution suggests that the alteration was permeability controlled.

8. Chloritoid is most common in rocks that form the stratigraphic footwall to the Michipicoten Iron Formation, but it has also been found in the stratigraphic hanging wall. La Tour (1980) recognized, in thin section, chloritoid in the mafic metavolcanic hanging wall rocks of the Helen Iron Range and the author has recognized it in outcrop. At the Rand No.2 Iron Range, chloritoid is equally developed above and below the iron formation. At the Helen Iron Range, the chloritoid occurs in the intermediate to felsic volcanoclastic rocks directly beneath the iron formation (Sage 1980). Samples of iron formation on the waste dump, at the MacLeod Mine and observations by Collins and Quirke (1926, p.69) indicate chloritoid occurs as isolated grains, streaks and bands within the iron formation. At the Josephine-Bartlett Iron Range, which is the eastern stratigraphic extension of the Helen Iron Range, the chloritoid occurs in pillowed and massive intermediate to mafic flows that lie stratigraphically below the cycle one intermediate to felsic metavolcanic rocks and some distance below the iron formation.

9. Although chloritoid zones are commonly associated with iron formations, particularly with the carbonate and sulphide facies, zones of chloritoid development without any associated iron formation are common.

10. While the long dimension of a chloritoid zone conforms to stratigraphy, the zone can encompass many individual flow units and is thus not confined to a specific unit. In addition, chloritoid-bearing pipe-like bodies that crosscut the stratigraphy, which could be interpreted as feeders or pathways for the fluids causing the alteration, have not been recognized.

11. The greater strike length over thickness of chloritoid units indicates the hydrothermal system was a broad regional aquifer controlled by rock permeability which is therefore related indirectly to the rocks.

12. Petrography indicates schistosity planes cut through some chloritoid porphyroblasts and bend around others. This suggests chloritoid development occurred late in the tectonic cycle and extended into the post tectonic period. The greater development of chloritoid not penetrated by schistosity planes suggests that greenschist facies regional metamorphism peaked shortly after deformation ceased.

The chloritoid alteration zone beneath the Helen Iron Range has been estimated at approximately 1000 by 2000 m in size by MacMillan (1981) and indicated to be approximately 600 by 2000 m in mapping by the author. Discontinuous chloritoid alteration occurs beneath the Lucy Iron Range. Calvert (1983, p.25-26) reported chloritoid in thin sections from the felsic footwall rocks of the Josephine Iron Range and the author suspects that it is present in footwall rocks of the Ruth and Eleanor Iron Ranges though not visually recognizable in outcrop. Masses and thin beds of nearly pure chloritoid may occur within the iron formation and are interpreted to represent interbedded altered metavolcanic detritus. In the northwest corner of Chabanel Township, two small chloritoid-bearing zones in second cycle intermediate to felsic metavolcanic rocks have been poorly outlined. No iron formation was found in association with these zones.

The chloritoid-bearing cycle one intermediate to mafic metavolcanic rocks at the top of cycle one volcanism below the Josephine-Bartlett Iron Range extends from near Goetz Lake in the west to Siderite Lake (Corbiere Township, outside the map area) in the east. This zone is on the order of 80 m thick and 9.6 km in length.

Goodwin (1964) studied the alteration of the intermediate to felsic metavolcanic rocks within the footwall of the Helen Iron Range and MacMillan (1980) examined the chloritoid-bearing part of this same stratigraphic section. Nebel (1982) and Morton and Nebel (1983) have completed additional work on this stratigraphic section including the chloritoid-bearing section. La Tour et al. (1980) examined chloritoid-bearing mafic lava overlying the Helen Iron Range and Worona (1982) and Lockwood (1983) have completed studies on carbonated, chloritoid-bearing mafic flows at the top of the mafic part of cycle one metavolcanic rocks beneath the Josephine Iron Range.

CHLORITOID ALTERATION - INTERMEDIATE TO MAFIC METAVOLCANIC ROCKS

A chloritoid-bearing mafic metavolcanic from the hanging wall of the Helen Iron Range was examined in thin section. The chloritoid occurs as tabular randomly oriented 1 to 2 mm crystals which in thin section are single twinned crystals with swallow-tail ends. The crystals are set in a fine-grained matrix of chlorite, carbonate and untwinned plagioclase. The texture of the fine-grained plagioclase is granoblastic. Trace to minor opaques are present.

A thin section of chloritoid-bearing mafic metavolcanic rocks below the Lucy Iron Range was also examined. The chloritoid occurs as tabular crystals up to 1 mm in random orientation. The crystals are twinned and display swallow-tail ends. The crystals are often

oriented perpendicular to schistosity and display some fracturing. Some quartz plus plagioclase aggregates of coarser texture may represent former amygdules. The fine-grained matrix consists of a mixture of quartz, untwinned plagioclase, carbonate, chlorite and sericite.

CHLORITOID ALTERATION - INTERMEDIATE TO FELSIC METAVOLCANIC ROCKS

Three thin sections were prepared from the chloritoid bearing felsic metavolcanic rocks located in the northwest corner of Chabanel Township. The chloritoid occurs as randomly oriented tabular twinned crystals up to 2 mm in size. The chloritoid crystals compose 5 to 15% of the rock. The ends of the crystals have a swallow-tail appearance and are set in a fine to very fine-grained matrix of chlorite, sericite, quartz, untwinned plagioclase, carbonate and opaques. The opaques appear to be dominantly iron oxides. Traces of pyrite and magnetite are present.

The minerals have a tendency to vary in grain size with various grain sizes tending to aggregate into distinct domains. The author considers this textural heterogeneity to reflect an original fragmental nature even though their clastic nature is not apparent on the outcrop surface and the rocks were dominantly mapped as sericite schists.

CHLORITOID - HISTORICAL BACKGROUND

Chloritoid porphyroblasts are common in the Michipicoten supracrustal rocks. Most reports describing this mineral in the Wawa area refer to it as otterlite, a manganese-bearing variety of chloritoid. However, microprobe studies completed by MacMillan (1981) and Lockwood (1983) have established the fact that the porphyroblasts are chloritoid.

Collins (1918, p.76) reported on the presence of chloritoid (otterlite) in the Goudreau area where he described it as occurring in random orientation in association with quartz and feldspar phenocrysts. The chloritoid (otterlite) was considered to be a primary constituent in relatively fresh rocks (Collins (1918, p.85).

Collins and Quirke (1926, p.29, 30) describe the chloritoid (otterlite) as composing 10 to 15% of the rock, as displaying frayed ends with straight basal planes, as displaying polysynthetic twinning and as containing abundant inclusions of groundmass minerals. Collins and Quirke (1926, p.30) observed schistosity planes cutting through some of the chloritoid (otterlite) crystals and it was considered by them to be a primary component of the rock. They also mentioned that chloritoid (otterlite) had been mapped as hornblende in the field (Collins and Quirke 1926 p.29).

Gledhill (1927, p.63) advocated a replacement origin for the sulphide facies of iron formation and in that connection suggested that the chloritoid (otterlite) that is commonly associated with some iron formations is the result of igneous action around basic intrusions. The replacement origin for sulphide facies iron formation has long been rejected (see section on origin of Michipicoten Iron Formation) and mapping has failed to disclose a close relationship between chloritoid and iron formation or mafic igneous intrusions.

Moore (1931, p.5, 6) interpreted the chloritoid (otterlite) as occurring in altered rocks and to be of metamorphic origin and not primary. The petrographic observations of Moore (1931, p.5) were similar to that of Collins and Quirke (1926, p.29,30) but an entirely different interpretation put on the observations. The interpretation of Moore (1931) remains accepted to this day.

Moore and Armstrong (1946) completed the largest volume of work on chloritoid (otterlite) principally in proximity to the Helen Iron Range. The chloritoid (otterlite) was observed by Moore and Armstrong (1946, p.97, 98) as occurring along cracks and as randomly oriented crystals in schistose rocks. Moore and Armstrong (1946, p.98) reported chloritoid (otterlite) to be more abundant in felsic rocks where it can be so abundant as to impart a bluish to dark grey colour to the rock. Selective replacement in bands were observed by Moore and Armstrong (1946, p.98) and the author has observed greenish black bands of nearly pure chloritoid in several specimens of iron formation.

In thin section, the chloritoid (otterlite) occurred as rosettes, sheaves and isolated rectangular crystals and displayed ragged ends and polysynthetic twinning (Moore and Armstrong 1946, p.98). Moore and Armstrong (1946, p.99) proposed that the chloritoid (otterlite) was introduced during igneous activity during Algoman time presumably at the same time the siderite was formed by replacement processes. Moore and Armstrong (1946, p.5) advocated a replacement origin for the siderite in the Michipicoten Iron Formation, a concept presently rejected by all investigators. They reported that the chloritoid displayed a strong preference to occur in felsic rocks (Moore and Armstrong 1946, p.98). This opinion may have been influenced by their study of the Helen Iron Range where chloritoid occurs dominantly in felsic rocks, however, on the basis of regional mapping the author would conclude that both mafic and felsic rocks are equally receptive to the presence of chloritoid development, if appropriate compositions are present.

Douglas (1953) argued for a replacement origin of the pyrite deposits within the Michipicoten Iron Formation in the Goudreau area. Chloritoid (otterlite) is commonly associated with the iron formation at Goudreau and Douglas (1953, p.315) related its formation to heat energy created by shearing and thrusting during folding. Douglas (1953,

p.315) presented no data to support this model and the dominate presence of randomly oriented chloritoid implies most chloritoid developed posttectonically.

SILICIFICATION - INTERMEDIATE TO MAFIC METAVOLCANIC ROCKS

On several small lakes south of Arliss Lake, several very small buff to light grey-white weathering outcrops are present. The outcrops are hard, siliceous and display occasional pillow selvages. The outcrops are thought to represent silicified intermediate to mafic metavolcanic rocks, however, there is insufficient outcrop to outline a possible area of silicification.

INTERMEDIATE TO MAFIC VOLCANIC ROCKS - GEOCHEMISTRY OF CHLORITOID ALTERATION

La Tour et al.(1980, p.165) reported that oxygen isotope data suggested that the mafic metavolcanic rocks above the Helen Iron Range interacted with seawater at 200°C or less to develop compositions appropriate for chloritoid growth. These rocks are low in alkalies, CaO, MgO and SiO₂ and high in iron (La Tour et al.1980, p.162). Within greenschist rank rocks of this composition, chloritoid development depends on temperature and water content. The absence of almandine indicates low temperature (La Tour et al.1980, p.172). La Tour et al. (1980, p.172) reported that the presence of quartz plus chlorite indicates equilibrium below 590°C and that chloritoid overgrows chlorite suggesting a sympathetic relationship between the two.

On the basis of these mineral relations, they suggest chloritoid formation below 475°C and above 425°C. These temperatures would be for regional metamorphism and unrelated to temperature of iron formation deposition. The reported mineral assemblage is chloritoid, chlorite, ilmenite, quartz (La Tour et al.1980, p.166), however, these rocks have been extensively carbonated and carbonate should be added to the assemblage.

Chloritoid formation within intermediate to mafic metavolcanic rocks at the Josephine Iron Range is dependent on bulk rock composition requiring low CaO and alkalies, enrichment in Al₂O₃ and a high Fe/Fe + MgO ratio (Worona 1982, p.22; Hoschek 1967). The mafic metavolcanic rocks at the Josephine Iron Range contain an assemblage of chloritoid in a matrix of quartz + sericite + chlorite + leucoxene (Worona 1982, p.22). However Worona (1982) did not mention carbonate in this assemblage. Within these chloritoid-bearing mafic metavolcanic rocks, chloritoid porphyroblasts occur in random orientation to

the schistosity and display a bow tie or hour glass morphology with inclusions of quartz, sericite and leucoxene (Worona 1982, p.23).

Worona (1982, p.23-24) observed the rocks to contain 10 to 50% idioblastic to subidioblastic carbonate in grains up to 2 mm in size which may enclose grains of quartz and sericite. Brown to yellow iron oxide along carbonate grain margins suggests a high iron content (Worona 1982).

Chlorite is present in amounts of 0 to 30% averaging 10% and chloritoid-free rocks are less sheared than chloritoid-bearing rocks (Worona 1982 p.24). Worona (1982, p.26) agreed with Kerrich and La Tour (1981) and MacMillan (1981) that the large alteration zone is a result of defocussed convective flow at temperatures below 200°C.

The trace elements Li, V, Cr, Co, Ni, Cu, Zn, Zr, Y, Sr and Ba were examined by Worona (1982 p.34-41) who found one third of the rocks to be unaffected when Gresen's (1967) equation are applied to check density and volume changes resulting from alteration. For those rocks affected, Gresen's (1967) equations indicate Cr, Cu, V and Y were added to the chloritoid-bearing altered rocks and Zn removed (Worona 1982 p.44). Worona (1982 p.43) proposed that the altered mafic rocks of the Josephine Iron Range went through a 5 step process; metasomatic alteration and development of a schistose fabric, minor structural deformation, chloritoid development, carbonate development and minor structural deformation.

Worona (1982) did not attempt to separate possible carbonate alterations related to iron formation development and those related to regional carbonatization which could confuse petrologic evolution of the rocks.

Lockwood (1983) studied 2 km of pillowed and massive mafic metavolcanic rocks at the top of the mafic part of first cycle volcanism below the Josephine Iron Range which lies immediately north of the map area. The study area of Lockwood (1983) adjoins that of Worona (1982) to the east. Mapping by the author has indicated that the zone studied by Lockwood (1983) and Worona (1982) extends for approximately 9.6 km and is approximately 80 m in width. The chloritoid occurs within pillows, along pillow margins, as bands in tuff layers, within thin units of iron formation and within interflow laminated tuffs. In pillowed rocks the chloritoid is concentrated in the selvages. The tuff layers within the iron formation may visually appear to be composed of only chloritoid.

Lockwood (1983, p.1) recognized a mineral assemblage of chloritoid + quartz + chlorite + paragonite + muscovite + siderite + ankerite. The accessory minerals pyrite, hematite, magnetite, ilmenite, zircon, sphene and rare epidote are present in minor amounts (Lockwood 1983, p.21, 25). As a result of interpreted seawater-basalt interaction, Al and Fe are concentrated; Mg, Si, CO₂ and to a lesser extent Na and K have

been added and Ca and Mn removed (Lockwood 1983, p.1). He proposed that the initial alteration minerals were a Fe-chlorite and smectite and that these minerals were precursors to chloritoid.

Random distribution of chloritoid indicates low water/rock ratios and diffuse flow, (Lockwood 1983, p.1). Chloritoid concentrated along fractures and chloritoid concentrated into bands indicates local focussed flow into more permeable layers (Lockwood 1983, p.1, 61). The concentration of chloritoid in pillow selvages reflects permeability control and local high water to rock ratios.

Lockwood (1983, p.1) proposed that at upper greenschist temperature and pressure conditions smectites became unstable and react to form mica plus chlorite. Chloritoid then forms at the expense of chlorite and possibly some mica at the upper limits of metamorphism, (Lockwood 1983, p.1).

The chloritoid-bearing rock contains 15 to 40% quartz, 5 to 50% chlorite as prochlorite and pennite, 0 to 30% mica as paragonite and muscovite, 2 to 50% iron-rich carbonate and 0 to 50% chloritoid, (Lockwood 1983, p.25, 28, 29). The quartz occurs in a grain size less than 0.01 mm and prochlorite is dominant over pennite (Lockwood 1983, p.25, 28). He reported that the micas display bending and kinking and upon probe analysis contain 2 to 7% Na₂O and up to 9% K₂O (Lockwood 1983, p.28). The carbonate is 0.01 mm in grain size, occupies open space fillings and overprints chloritoid, chlorite, mica and quartz (Lockwood 1983, p.28, 29). The presence of dark brown patches of iron oxides prompted Lockwood (1983, p.29) to classify the carbonate as dominantly siderite.

The chloritoid is randomly oriented as individual crystals, or occurs as subparallel crystal aggregates with hourglass or bow-tie configuration and displays polysynthetic twinning (Lockwood 1983, p.36).

He observed that the chloritoid overgrows the foliation, has well defined grain boundaries and displays inclusion trails. Lockwood (1983, p.36) also observed carbonate inclusions within the chloritoid and that mica commonly occurs along the crystal edge. Lockwood (1983, p.37) reported that the mica weaves around chloritoid grains and may change direction at the chloritoid grain edges. No reaction relationships between chloritoid and mica were observed (Lockwood 1983, p.31). He reported that chloritoid and chlorite do show an antipathic relationship and the chloritoid shows a fairly uniform composition. This composition is FeO, 24 to 27%; MgO, 1.5 to 3.5%; MnO, 0 to 1.0%; Al₂O₃, 38 to 43%; and SiO₂, 25 to 26% (Lockwood 1983, p.43). He reported that Na, K, Ca, Ti and Cr are almost totally absent from the chloritoid mineral (Lockwood 1983, p.43). Lockwood (1983, p.45, 62) suggested that a defocused hydrothermal fluid composed dominantly of seawater which has reacted with basalt to form Fe-chlorite and smectite of appropriate composition was

developed so that under conditions of diagenesis - metamorphism chloritoid could form. Chloritoid is after chlorite, and mica after smectite (Lockwood 1983, p.62). The chloritoid distribution suggests permeability control of the altering fluid which was defocussed (Lockwood 1983). Fractures controlling chloritoid distribution were probably originally cooling cracks in the flows. Lockwood (1983) suggested that chloritoid formed at temperatures less than 590°C or at upper greenschist rank conditions.

At the Josephine Mine, Lockwood (1983, p.55) reported that Si, CO₂, Al and Fe have increased and that locally Na and K have increased with respect to fresh basalt. The high Fe and Al contents are a result of their immobility during alteration and represent original contents. Lockwood (1983, p.54, 60) proposed that at appropriate pressures and temperatures, the micas oriented themselves to form a schistosity after which the chloritoid formed. He proposed that post-chloritoid deformation kinked the micas and that minor shearing occurred (Lockwood 1983, p.60). Lockwood (1983, p.62) recognized two and suggested the possibility of three deformation periods.

INTERMEDIATE TO FELSIC METAVOLCANIC ROCKS - GEOCHEMISTRY OF CHLORITOID ALTERATION

Studies concerning the development of chloritoid in intermediate to felsic metavolcanic rocks has concentrated on the footwall rocks of the Helen Iron Range and to a more limited extent the Lucy Iron Range.

Goodwin (1961, 1962, 1964) examined the altered footwall rocks of the Helen Iron Range. While Goodwin (1961, 1962, 1964) does not discuss chloritoid, the area of his study contains abundant occurrences of chloritoid. Goodwin et al. (1985, p.72) referred to the chloritoid as otterlite and considered its presence to indicate an alteration pipe below the Helen Iron Range. Goodwin (1962, p.573, 1961, p.25) observed that the most extensive carbonate development and alteration spatially occurred within 30 to 167 m of the iron formation and that CO₂, FeO, MnO and MgO were added and Si, Ca and alkalies removed from the rock. He calculated that the SiO₂ leached from the footwall felsic rocks was equivalent to that found in the overlying iron formation. He attributed the alteration process to be one of hot spring activity in which Al₂O₃ is immobile (Goodwin 1961, p.25, 1962, p.573).

Goodwin (1961, p.25, 1964, p.700, 702) observed alteration to a depth of 1000 m and implied that it occurred while the rocks were subhorizontal. Any lateral variation is a function of original composition of the units and any vertical variation is the result of superimposed chemical alteration (Goodwin 1964, p.684). The added components CO₂, FeO,

MnO and MgO are from an unknown magmatic source and represent the product of silicate mineral breakdown in the presence of a magmatic CO₂-bearing fluid, (Goodwin 1961 p.26 1964 p.701). He observed the footwall rocks to be deficient in Co, Ni, Zr, Zn, Cr; similar in Cu, V and Pb and enriched in B and As relative to world averages for rocks of these compositions (Goodwin 1961 p.26, 1964 p.716).

Goodwin (1964, p.696, 701) used Al₂O₃ to classify his altered rocks under the assumption that Al₂O₃ was immobile during alteration even though some slight mobility was recognized. He used a value of less than 13% Al₂O₃ to define rhyolite which lies at the west end of the Helen Iron Range and greater than 13% Al₂O₃ to define dacite which lies at the east end of the range. By contouring Al₂O₃, Fe, MgO, CaO, CO₂ and SiO₂ a easterly plunge of 35° in the alteration pattern was suggested by Goodwin (1964, p.696-700). The easterly plunge is consistent with clast elongation and minor fold axis observed by the author which plunge east at 55 to 60°.

The easterly plunge to the alteration pattern may in part be the result of a tectonic event.

The alteration zone below the iron formation is uniformly thick regardless of rock composition (Goodwin 1964, p.700). The similar elemental contour patterns for both mobile and presumed immobile elements suggests to the author that all elements are to a more or less mobile and that rock classification on the basis of Al₂O₃ content should be done with caution. Goodwin (1964, p.701) related MgO anomalies at the east end of the Helen Iron Range to the presence of metadiorite intrusions and observed the CO₂ contents to be highly erratic. He did not attempt to separate carbonate alteration due to iron formation deposition from that introduced during regional metamorphism.

Goodwin (1964, p.702) concluded that the more felsic volcanic rocks were more severely altered and that CaO lost from the dacites appeared to be gained by the rhyolites.

Goodwin (1964, p.704) considered the altering fluid to be of both magmatic and seawater origin and to be charged with bicarbonate plus sulphur. This fluid altered the footwall rocks under low pressure conditions and upon entering the subaqueous environment deposited the iron formation as a chemical sediment. The alteration and iron formation deposition are considered to be the same event (Goodwin 1964, p.717).

Goodwin (1964, p.716) calculated that the weight of SiO₂ in the iron formation approximates that lost from the footwall metavolcanic rocks and proposed that the iron in the iron formation resulted from the alteration of footwall rocks. He suggested that some Al₂O₃ may have been leached from the footwall and therefore is not immobile as he assumed in separating dacite from rhyolite. The high B and As of the Michipicoten Iron Formation was attributed to volcanic fumarolic activity and is of magmatic origin (Goodwin

1964, p.716) The author considers carbonate alteration at the Helen Iron Range to be a product of two events; an alteration associated with iron formation deposition, and a regional metamorphic event. Therefore, bulk carbonate content cannot be used to outline a carbonate alteration halo associated with iron formation deposition.

The author concurs with Goodwin (1964) that the silica and iron making up the iron formation is likely derived by alteration of the underlying metavolcanic rocks. The high iron tholeiitic lavas of the footwall would be a good source of iron.

LeSeelleur (1980, p.17) studied the footwall rocks of the Lucy Iron Range and found the footwall rocks to be composed of quartz carbonate, muscovite, chlorite and pyrite. LeSeelleur (1980, p.19-20) used A-C-F-K plots to indicate that the style of alteration is of a porphyritic type. This alteration is characterized by Mg-plus Na-metasomatism and replacement of the alkali feldspar by chlorite and iron carbonate (LeSeelleur 1980, p.19-20).

Carbonate makes up approximately 30% of the footwall rocks and is dominantly ankerite followed by siderite and calcite (LeSeelleur 1980, p.21). The carbonate occurs as very fine-grains in the groundmass, coarse-grained vuggy aggregates and as veins: The chlorite is present in quantities up to 5 to 10% as massive to irregular aggregates and subhedral to anhedral plates (LeSeelleur 1980, p.23). Chlorite plates occur in the centre of coarse aggregates of quartz, muscovite, carbonate and in quartz cores of massive sulphide aggregates (LeSeelleur 1980, p.23).

Chloritoid, when present, occurs as metacrysts bordered by quartz plus carbonate and containing inclusions of carbonate (LeSeelleur 1980, p.23). The metacrysts are described as up to 1 mm in size, random in orientation and appear to have undergone carbonate replacement. LeSeelleur (1980, p.25) reported that schistosity planes bend around the crystals implying pre-tectonic growth. The random orientation of the chloritoid metacrysts suggests otherwise.

LeSeelleur (1980, p.26) reported that the muscovite occurs as grains up to 0.5 mm in size, in both aggregates and as individual grains, in oriented grains as fine-grained felty vein-like structures, and in random orientation in the groundmass.

LeSeelleur (1980, p.29) studied both minor and major element chemistry on some Lucy footwall rocks. These data are presented in Table 8.

LeSeelleur (1980, p.33) interpreted the chemistry to indicate an original dacite composition and that the metals Fe, Mn, Co, Cu, Zn, Ag, Cd, As, Sb and possibly Mg are enriched in the altered footwall rocks. The fluids causing the alteration were interpreted to be from a differentiating mafic to ultramafic source in equilibrium with the source rocks (LeSeelleur 1980, p.33, 37).

LeSeelleur (1980 p.33-34) observed that the elements Mg, Ca, V, Nb and Cr were not depleted with respect to normal granite however Na, K, Rb, Sr, Be, Ba, B, Al, Si and Ti were depleted. Chlorine was not detected in the rocks.

LeSeelleur (1980, p.39-40) used ratios of Al and Ti, to Y, Zr and V to propose that elements of dissimilar chemical behavior behaved similarly thus implying that large quantities of fluid were involved in the alteration to overcome insolubilities of the immobile elements Al and Ti.

On the basis of mass transfer equations, LeSeelleur (1980, p.45) found silica to be depleted 20%, sodium 1.5% and potassium 1.5% and Fe, Mn, Mg and Ca enriched relative to unaltered rhyolite to dacite.

The pattern of alteration is one of a cycle of enrichment to depletion and then element enrichment. Mass transfer has not been uniform and a random pattern or process has occurred suggesting fluid ponding and recirculation of fluid (LeSeelleur 1980 p.45).

Using the solubilities of elements at 200 to 300°C and assuming a hot spring situation, high fluid/rock ratios will concentrate base metals but not W and Ag (LeSeelleur 1980 p.(53, 55). He proposes that the movement of large quantities of fluid through the footwall rocks may explain the absence of rare metals such as Ag and W relative to other base metals in the wallrock. A focused hydrothermal system will tend to concentrate the rare metals, however, the Lucy system is diffuse as indicated by the pervasive alteration, hence the elements such as Ag and W are not concentrated (LeSeelleur 1980, p.56). Table 9 gives calculated water/rock ratios calculated by LeSeelleur (1980) for various elements.

Eden (1980) has also examined the footwall rocks of the Lucy Iron Range. Eden (1980, p.46) observed that the chloritoid-bearing rocks of the Lucy Iron Range occurred only within the immediate footwall rocks and dominantly within breccia fragments rather than matrix of a mafic breccia unit. He considered the chloritoid to be the result of a metamorphic overprint of a footwall alteration zone. Eden (1980, p.45) found the mineral assemblage sericite + chlorite + epidote + chloritoid $\pm$ biotite which is characteristic of a transition between the chlorite and biotite zones of the greenschist rank of regional metamorphism. He observed chlorite after biotite indicating that the biotite had undergone retrograde reaction. The random orientation of the chloritoid porphyroblasts indicates a post-deformational period of growth (Eden 1980, p.46). Abercrombie (1981, p.29-32) also found stilpnomelane, hematite, quartz and carbonate in the footwall metavolcanic rocks.

Eden (1980, p.46) could not determine if the sericite and ankerite are due to ore-related or metamorphic processes. The absence of fracture or schistosity control for the sericite suggests that it is metamorphic in origin. Redistribution of the ankerite into veins has obscured its original relationship to the rocks.

The overlying intermediate to mafic metavolcanic rocks are heavily carbonated and contain poikiloblastic orange-brown carbonate rhombi between 0.2 and 4 mm in size (Eden 1980, p.33). The ankeritic carbonate may form up to 35% of the rock and veining by quartz plus ankerite is common (Eden 1980, p.33). Least altered intermediate to mafic metavolcanic rocks consist of fine-grained corroded laths of sericitized and chloritized plagioclase subophitically enclosed in a very fine-grained chlorite-rich groundmass (Eden 1980, p.34). He interpreted the groundmass to be a devitrified glass (Eden 1980, p.34). Eden (1980, p.34) also identified epidote, Fe-oxides, pyrite, sericite and chlorite. Some specimens contain microphenocrysts of altered plagioclase and some ovoid quartz plus carbonate aggregates rimmed with chlorite may be former amygdules (Eden 1980, p.35). A fine-grained intermediate to mafic metavolcanic rock from a pillowed unit displays 0.2 mm curved, carbonatized and sericitized plagioclase laths in a chlorite-rich groundmass resembling a quench texture (Eden 1980, p.35). A weak alignment of these tiny laths suggest a flow texture (Eden 1980, p.35).

MacMillan (1981) mapped the distribution of chloritoid-bearing rocks beneath the Helen Iron Range. He considered the footwall rocks to have been originally nearly all dacitic in compositions on the basis of trace element data (MacMillan 1981, p.20) and to have lost Si, Ca, Na and to have gained Al and Fe (Table 10). The chloritoid alteration is proximal to the iron formation, chemically heterogeneous, dish-shaped and not pipe-shaped in plan view and is the product of defocussed discharge and suppressed convective flow (MacMillan 1981, p.1). This implies a low water/rock ratio and longer fluid residency permitting rocks-fluid equilibrium to be established. The proposed low water to rock ratio is in agreement with Lockwood (1983) but at variance with the high water to rock ratio suggested by LeSeelleur (1980).

The altered rocks are 40 to 80% quartz, 30 to 50% sericite, 3 to 20% chloritoid, 3 to 30% chlorite and 3 to 40% carbonate (MacMillan 1981, p.15). The dominant carbonate is siderite followed by ankerite, followed by dolomite and the minor or accessory minerals are epidote, clinozoisite, ilmonite, stilpnomelane, plagioclase, sphene, hematite, magnetite and pyrite (MacMillan 1981, p.16). MacMillan (1981, p.15) described the texture as lepidoblastic.

The chloritoid occurs as randomly oriented crystals with radial and bow-tie structures displaying lamellar and penetration twinning (MacMillan 1981, p.15). He reported the presence of quartz inclusions within the chloritoid and that the carbonates may replace chloritoid (MacMillan 1981, p.15). Chlorite is present as matted aggregates and a sympathetic quartz-chlorite and an antipathetic chlorite-chloritoid relationship exists (MacMillan 1981, p.16). The carbonate minerals, quartz, sericite, chlorite, epidote and

clinozoisite are commonly associated in spherulitic cavities or in mineral aggregates relict after former mineral crystals (MacMillan 1981, p.16).

MacMillan (1981, p.17) reported the presence of chloritoid in all rock types with the greatest concentrations in fragmental rocks and that some mafic lenses may be 80% chloritoid. MacMillan (1981, p.17) reported chloritoid distribution is erratic with respect to rock units and that it may be just as well-developed in the extremities of the zone as in the central area.

The author and MacMillan (1981) have observed that chloritoid may be concentrated in clasts over matrix or vice versa and that chloritoid-poor clasts may lie adjacent to chloritoid rich clasts. There is generally no visual compositional difference between chloritoid-poor and chloritoid-rich clasts or matrix. If chloritoid is concentrated in matrix, it may show a preference to be concentrated along clast margins. Chloritoid also occurs along straight fractures, but is uncommon in this habit. This style of chloritoid development may reflect alteration along cooling cracks (Plate 36).

Since the footwall rocks are considered to be of one type (fragmental volcanic rocks), using Zr/TiO₂ versus Nb/Y plots the heterogeneous compositions reflect differing degrees of alteration (MacMillan 1981, p.21, 22). Goodwin (1964) assuming Al₂O₃ immobility compared the Al₂O₃ contents with unaltered rhyolite and dacite to classify the rocks, however, as discussed by MacMillan (1981, p.20) the leaching of Ca, Si and alkalis enhances the Al₂O₃ content and thus it does not compare with original rock compositions. Gresen's (1967) equations relating density and volume changes resulting from alteration were applied by MacMillan (1981, p.22) and it was found that the rocks are depleted in Si, Ca, Na, K, enriched in Fe and mildly enriched in Mg and Mn. These results agree with Goodwin (1964).

The chloritoid distribution is a function of rock composition which must have high Al₂O₃, low CaO and alkalis and a high FeO/FeO + MgO ratio (MacMillan 1981, p.26). The heterogeneous chemical behavior suggests irregular and alternating fluid pathways and the non-systematic mass transfer implies fluid flow in a aquifer of high tortuosity (MacMillan 1981, p.31). MacMillan (1981, p.38, 39) correlated CaO, Na₂O and K₂O depletion with feldspar hydrolysis and suggests that alteration favourable to chloritoid development is favoured by high hydrothermal fluxes. Chloritoid concentration within clasts, along clast boundaries and along fractures is therefore a function of permeability contrasts.

The chloritoid is randomly oriented with respect to the sericitic fabric and MacMillan (1981, p.46) suggested it grew while the stratigraphy was flat lying. MacMillan (1981, p.46) suggested nontronite (Na_{0.3}Fe₂³(Si,Al)₄O₁₀(OH)₂·nH₂O) was a pre-cursor to chloritoid. The sericitic fabric was considered by him to represent primary layering and the footwall

rocks were interpreted by him as not displaying polyphase deformation. The author considers the schistosity to be in part tectonic and that it commonly follows original bedding. The random nature of chloritoid orientation suggests an essentially posttectonic formation. The lack of deformation suggested by MacMillan (1981) contrasts with two to three periods of deformation (one post-chloritoid) suggested by Lockwood (1983). The author is in agreement with Lockwood that polyphase deformation has occurred.

Osterburg (1982) only briefly described alteration of the intermediate to felsic metavolcanic rocks lying stratigraphically below the Helen Iron Range. Osterburg (1982, p.42) described four types of fracture fillings or veining within the footwall rocks. These were; 1) early quartz veining; 2) quartz-siderite-magnetite veining; 3) sericite-chlorite-chloritoid-epidote-stilpnomelane veins (observed in thin section only); 4) quartz veining. The author has observed the quartz veining and chloritoid-bearing fractures within the intermediate to felsic metavolcanic rocks of the footwall.

Using the Beswick and Soucie (1978) model, for determining the affects of metasomatism, Osterburg (1982, p.55) found that SiO_2 had been added, FeO plus MgO , CaO and Na_2O had been removed and K_2O had been both added and removed in various samples. He suggested that the elements lost in alteration of the felsic metavolcanic rocks are now present in the Helen Iron Range (Osterburg 1982, p.55).

Nebel (1982) completed a detailed study of the footwall rocks of the Helen Iron Range. Portions of this work concerned with felsic volcanic stratigraphy were published by Morton and Nebel (1983). Morton and Nebel (1984) discussed the alteration of the volcanic rocks around the Helen Iron Range.

Nebel (1982, p.1) interpreted the rocks as being deposited subaerially to subaqueously and that four alteration types are recognizable, 1) sericite, 2) chlorite, 3) chloritoid and 4) ankerite. These alteration types have been superimposed upon by a fifth type that is representative of greenschist rank regional metamorphism (Nebel 1982, p.2).

The fluid causing the alteration at the Helen Iron Range is an acidic K-rich fluid of shallow circulating seawater (2 to 3 km) which migrated upward in response to heating by subvolcanic intrusions (Nebel 1982, p.102; Morton and Nebel 1984, p.1319). The purposed alteration zone is approximately 6 by 2 km in size (Morton and Nebel 1984, p.1319). Nebel (1982, p.102) suggested that a subvolcanic intrusion provided a heat source to drive the hydrothermal system.

Turek et al.(1982, p.1621) obtained a U-Pb isotopic ages of 2749 ± 2 Ma. on the felsic metavolcanic rocks immediately below the Helen Iron Range which is comparable to the U-Pb isotopic age of 2745 ± 3 Ma. obtained by Sullivan et al.(1985) on the Jubilee Stock south of Wawa Lake. The Jubilee Stock could have provided a heat source to drive a

hydrothermal system in the area of the Helen Iron Range. Chloritoid zones, however, occur throughout the Wawa supracrustal sequence far removed from the Jubilee Stock or any other potential heat source. The Jubilee Stock is separated from the metavolcanic rocks north of Wawa Lake by the Wawa Lake Fault making it difficult to determine the original relationship of the stock to the metavolcanic rocks, the alteration zone and iron formation.

The four zones of alteration discussed by Nebel and Morton (1982) and Nebel (1983, 1984) are summarized below going from the least altered to most altered assemblage.

LEAST ALTERED 'GREENSCHIST' ASSEMBLAGE

The least altered assemblage is representative of greenschist rank regional metamorphism. In the felsic metavolcanic rocks, the mineral assemblage is albite + quartz + sericite + ankerite and within the mafic intrusion the assemblage is actinolite-epidote + chlorite + albite + ankerite (Morton and Nebel 1984, p.1322, 1323). The grain size within these rocks are reported by them to vary between 0.1 and 2.0 mm.

Nebel (1982, p.69, 70) classified the rocks below the Helen Iron Range as being all of greenschist rank and the schistosity is the result of regional metamorphism. He interpreted the rock mineralogy of sericite, chlorite, chloritoid and ankerite to indicate that hydrothermal alteration had occurred and that changes in rock mineralogy and texture is in response to regional metamorphism and not regional chemical alteration (Nebel 1982, p.69,70) associated with regional metamorphism. The high normative corundum content of the altered rocks supports hydrothermal alteration to generate the proper precursor rock compositions.

SERICITE ALTERATION ASSEMBLAGE

The sericite alteration assemblage is very widespread, stratigraphically conformable and recognized in the field by its yellowish green colour and well foliated nature (Morton and Nebel 1984, p.1322, 1324). This zone is approximately 5 by 1.5 km and is gradational into lesser altered rocks and the chlorite alteration zone (Morton and Nebel 1984, p.1324).

The fluid causing the alteration is an acidic K-rich solution of shallow circulating seawater (1 to 3 km) which migrated upward in response to heating by subvolcanic intrusion (Nebel 1982, p.102; Morton and Nebel 1984, p.1319). The K-rich fluid reacted with feldspar in the volcanic rocks to form sericite plus quartz by K addition and Na removal leading to an impermeable sericite-quartz cap rock, (Nebel 1982, p.102; Morton and Nebel 1984, p.1329, 1326). Nebel (1982, p.104) and Morton and Nebel (1984, p.1329, 1330) suggested that deep circulating seawater (greater than 3 km) reacted with basalt to become enriched in Fe, Mg,

Mn, Ca and CO₂, while adding Na to the basalts, which then migrated upward to the sericite-quartz cap rock. The CO₂ could be from leaching of the underlying volcanic rocks or by metamorphic devolatilization during greenschist to amphibolite metamorphism (Morton and Nebel 1984, p.1330). The sericite-quartz cap rock was broken and fractured by hydrothermal explosions and the upward moving fluid reacted with the early formed cap rock (Nebel 1982, p.104). This upward migrating fluid added Fe, Mg, Mn and removed K from the sericitic cap forming a chlorite $\pm$ pyrophyllite assemblage at the expense of the sericite-rich rock (Nebel 1982, p.104, 106; Morton and Nebel 1984, p.1330). At conditions of greenschist facies, regional metamorphism the chlorite $\pm$ pyrophyllite assemblage was later converted to chloritoid + quartz (Nebel 1982, p.106).

At the seafloor, a sudden release of pressure coupled with mixing of cool seawater will decrease CO₂ solubility causing carbonate (siderite) precipitation (Nebel 1982, p.106; Morton and Nebel 1984, p.1330). Even though Nebel (1982, p.2) and Morton and Nebel (1984, p.1330) advocated that pyrophyllite or an alumina silicate was at one time present in the Helen footwall rocks, they did not identify its presence nor has it been reported by other investigators such as Goodwin (1964) and MacMillan (1981).

Sericite occurs as disseminated flakes, plate-like aggregates, fine-grained foliated masses, replacement of juvenile constituents and in veinlets (Morton and Nebel 1984, p.1324). Plagioclase crystals are a good precursor of sericite alteration since in the least altered rocks sericite occurs as disseminated flakes and as narrow rims around plagioclase phenocrysts while it completely replaces plagioclase in the sericite alteration zone (Morton and Nebel 1984, p.1324). The sericite alteration is best developed in ash beds, matrix of basal beds of pyroclastic flows, pumiceous fragments, along fractures and adjacent to zones of intense alteration (Morton and Nebel 1984, p.1324).

Nebel 1982, p.72) reported that a sericite alteration assemblage consists of sericite, 25 to 80%; quartz plus plagioclase, 16 to 75%; ankerite, 0 to 11%; chlorite, 0 to 5%; chloritoid, 0 to 3%; and stilpnomelane (0 to 3%). The grains size is < 0.02 mm and the sericite may be pseudomorphic after plagioclase and fill lithophysae. Morton and Nebel (1984, p.1324) reported a slightly different mode for rocks of this alteration zone.

CHLORITE ALTERATION ASSEMBLAGE

A zone of chlorite alteration grades inward from the sericite zone to the contact area of more intense chloritoid alteration. The chlorite is exposed as discontinuous pods and lenses and is formed at the expense of the sericite in response to the addition of Fe, Mg, Mn, Ca, Ti and removal of Na and K (Morton and Nebel 1984, p.1324, 1326). They

recognized the presence of chlorite by the green colour of the outcrops and it is best developed in massive flows (Morton and Nebel 1984, p.1324). The chlorite occurs as disseminated flakes, fine-grained platy aggregates, foliated masses and narrow veinlets which may give rise to pseudobreccia textures (Morton and Nebel 1984, p.1324).

The chlorite assemblage is reported to have 10 to 91% chlorite, 10 to 64% quartz, 0 to 32% sericite, 0 to 13% ankerite, 0 to 4% chloritoid and 0 to 10% stilpnomelane (Nebel 1982, p.72-73). Morton and Nebel (1984, p.1324) reported a slightly different mode and the presence of trace to 5% albite. Nebel (1982, p.72, 73) described the grain size as + 0.02 mm and that the chlorite occupies veinlets, fills lithophysae and on the basis of X-ray diffraction patterns may be an aphrosiderite ripidolite $[(\text{Mg}, \text{Fe}^{+2})_9 \text{Al}_6\text{Si}_5\text{O}_{20}(\text{OH})_{16}]$.

CHLORITOID ALTERATION ASSEMBLAGE

A third alteration assemblage referred to as the chloritoid assemblage is described by Nebel (1982, p.73, 78) and Morton and Nebel (1984, p.1324) as a discordant zone that narrows and pinches out to the southwest and is gradational into the chlorite zone (Morton and Nebel 1984, p.1324). Morton and Nebel (1984, p.1327) reported that the chloritoid zone represents the addition of Fe, Mn, Ti and Na plus K removal. The chloritoid is formed from chlorite in response to a isochemical regional greenschist rank metamorphic event and can be observed overgrowing chlorite in the area of transition into the chlorite alteration zone (Morton and Nebel 1984, p.1328, 1325). The chloritoid occurs in quantities varying between 20 and 80%, in crosscutting fractures between 10 and 35% and in matrix and lithic fragments between 12 and 75% (Morton and Nebel 1984, p.1324). They reported that the chloritoid occurs as subhedral porphyroblasts ranging from 0.2 to 7.0 mm in maximum dimension, as radial rosettes, as sheaf-like aggregates and as individual laths (Morton and Nebel 1984, p.1325). The laths display lamellar twinning and hour-glass structure (Morton and Nebel 1984, p.1324, 1325). Nebel (1982, p.73, 74) reported that the chloritoid alteration assemblage is composed of chloritoid, 5 to 30%; andalusite, 3 to 25%; quartz, 33 to 88%; sericite 1 to 50%; ankerite 0 to 30%; chlorite 0 to 1%; and stilpnomelane 0 to 1%. This mode is at variance with the mode reported later (Morton and Nebel 1984, p.1325). Morton and Nebel (1984, p.1325) reported that chlorite is absent from the innermost part of the chloritoid zone and that andalusite plus quartz is present. Andalusite occurs as poikiloblasts varying from 0.3 to 10 mm in diameter and as small 0.03 to 0.4 mm ragged grains interstitial to chloritoid (Morton and Nebel (1984, p.1325). They reported the presence of andalusite to be more common along flow boundaries and did not identify pyrophyllite or kaolinite which

they proposed as the precursor to chloritoid (Nebel 1982, p.73, Morton and Nebel 1984, p.1328).

ANKERITE ALTERATION ASSEMBLAGE

This zone is restricted to the area directly below the Helen Iron Range and is approximately 2000 by 65 to 130 m in size (Morton and Nebel 1984, p.1325). They reported that this alteration zone is gradational into the siderite of the iron formation even though the contact is sharp where exposed in other iron ranges and was indicated by Goodwin (1964, p.709) to be sharp at the Helen Iron Range. The altered rocks weather rusty brown and the matrix to the altered pyroclastic rocks may be nearly completely replaced while the lithic fragments are only carbonate-rich (Morton and Nebel 1984, p.1325). The ankerite occurs as rhombohedral crystals. Nebel (1982, p.100) reported that the assemblage is carbonate 33 to 91%; quartz, 5 to 48%; sericite; 2 to 40%; chlorite 0 to 10% and chloritoid, 0 to 2%. This mode is slightly different from the mode reported by Morton and Nebel (1984, p.1325) who also reported trace to 5% stilpnomelane and trace to 10% siderite. Nebel (1982, p.78, 79) reported that the carbonate species is difficult to identify in thin section but on X-ray diffraction patterns dolomite, ankerite and siderite were identified. The identification of siderite was restricted to rocks immediately below the iron formation and to the matrix of hydroexplosion breccias. Dolomite occurred as fracture fillings and all other carbonate is ankerite.

DISCUSSION

Nebel (1982, p.80) indicated that the four alteration assemblages display both sharp and gradational contacts with each other and that the degree of alteration is permeability controlled with more dense flows and fragmental rocks displaying the least alteration. He has also reported that alteration has generated some pseudo-fragments where highly altered rock encloses remnants of less altered rock. The model is one of seawater-rock interaction generating a K-rich solution which reacted with the surface rocks converting plagioclase to sericite plus quartz and removing Na (Morton and Nebel 1984, p.1319). This formed an impervious cap rock. Deep circulating fluids reacted with mafic rocks and transported Fe, Mn, Ca and CO₂ to the surface and reacted with the sericite cap rock producing a chlorite plus aluminosilicate alteration and removing K (Morton and Nebel, (1984, p.1319). At the seafloor, boiling drove off CO₂ precipitating iron carbonates. Greenschist rank regional

metamorphism converted primary alteration mineral assemblages into the present assemblage (Morton and Nebel 1984, p.1319).

Morton and Nebel (1984, p.1328, 1325) suggested a seawater dominated hydrothermal fluid which generally added Na and removed K. They considered Al, Si and Ti as immobile and Fe, Mg, Mn and Ca variation to be a function of the carbonate mineralogy.

Nebel (1982, p.89) has previously interpreted his data to indicate that all elements examined were mobile. The intense alteration observed in some outcrops which now are more than half carbonate would suggest to this author that the earlier conclusion of Nebel (1982) needs to be confirmed or rejected by additional study. The author concurs with Nebel (1982, p.89) that replacement or alteration appears to be one of essentially constant volume since the primary structures and clast shapes are so well preserved.

ALTERATION - SUMMARY

The Wawa supracrustal rocks represent a typical Archean telescoped metamorphic assemblage. The supracrustal rocks have been metamorphosed to amphibolite rank along the margins and display a typical greenschist rank within the core. The amphibolitic rank rocks have been retrograded to varying degrees and are now dominantly greenschist facies rank.

Granitic stocks intruded into the supracrustal rocks have a thermal aureole, possibly of epidote-hornfels rank that has been retrograded to greenschist rank in response to regional metamorphism.

Rocks marginal to the Firesand River Carbonatite have been metasomatized (finitized) and diabase dikes nearly always have a hornfelsed contact where they cut low grade greenschist facies supracrustal rocks.

The pervasive carbonate alteration north of Wawa Lake extending northeast to Goudreau is the product of metamorphic degassing of a carbonate-rich volcanic stratigraphy in the root zone of the Wawa supracrustal sequence. This event affects all volcanic cycles and may be either syn-folding or post-folding and took place after volcanism and supracrustal development had occurred.

Chloritoid alteration is widespread, conformable with stratigraphy and not necessary associated with iron formation. It represents the effect of a non-focussed, permeability-controlled, hydrothermal system that altered the metavolcanic rocks to compositions appropriate to form chloritoid in a post-deformation regional greenschist metamorphic event. The hydrothermal system probably existed at 200°C or less at surface, represents low water/rock ratios and was dominantly composed of seawater that had circulated to depth and reacted with mafic rocks. The fluid flow was highly variable representing a high degree of

tortuosity and the low water/rock ratios suggest long residency times and the possibility of rock-fluid equilibrium. Locally high water/rock ratios are indicated in areas of high permeability such as along fractures and through coarse breccia units.

The common occurrence of chloritoid zones associated with iron formation suggests that in at least some of these hydrothermal alteration events the alteration accompanied iron formation deposition. If this relationship is true, the iron formation represents an accumulation of elements resulting from deep circulation and alteration of the volcanic rocks. The iron formations are therefore the result of metamorphic devolatilization at depth resulting in removal at depth of those elements needed for iron formation deposition. The deposition took place at the surface during a hiatus in volcanism. The presence of chloritoid bearing zones not associated with iron formation and occurring in the upper part of cycle two volcanic rocks indicates that the hydrothermal aquifers were not always associated with iron deposition. The stratigraphic distribution also indicates that the hydrothermal zones were present at different times during the evolution of the belt and do not represent a single isolated event.

The presence of schistosity planes penetrating through some chloritoid porphyroblasts but curving around most porphyroblasts implies that some chloritoid was syntectonic and some posttectonic. The petrographic observations suggest deformation and regional metamorphism giving rise to chloritoid development were the same event which straddled the syntectonic - posttectonic period. The greater development of randomly oriented chloritoid not cut by schistosity implies that the regional metamorphic event peaked shortly after deformation ceased.

STRUCTURAL GEOLOGY

The geologic structure of the Wawa supracrustal rocks is complex and a discussion of structure within the map area cannot be divorced from structures external to them. Mapping of the highly folded and faulted supracrustal rocks has not resolved the problem as to whether the sequence was originally synformal or monoclinial.

The great lateral continuity of major lithologic packages and iron formation units north of Wawa Lake infers control by faulting, rifting, or fracturing along which essentially coeval volcanism has occurred. Volcanism repeated itself in at least three cycles before subsequent tectonism deformed the belt. Major tectonic events between the volcanic cycles could not be identified. The rocks of the various cycles appear to be conformable a relationship that may prove to be in part tectonic on further study.

The early form of the Wawa supracrustal rocks and the controlling structures are unknown, however, the author is of the opinion that at least some of the early deformation is likely related to the development of the Kapuskasing Structural Zone to the east. The author recognizes the possibility of four tectonic events and Massey (1985, p.52) recognizes at least three immediately south of the map area.

JUBILEE STOCK

The stock has a northeast-trending long axis striking at approximately 20° and is approximately 6.0 km long and approaches a maximum width of 1.3 km. The east margin of the stock is an intrusive breccia composed of a variety of angular metavolcanic rock types set in a fine-grained diorite to granodiorite matrix. The volcanic rock clasts display sharp contacts with the intrusive rocks and little evidence of assimilation by the intruding granitic magma.

The stock locally may be composed of nearly half xenolithic metavolcanic material which in such large quantities and size indicate that the stock is presently exposed at a high structural level. Along the flanks of the Jubilee Stock, several rock units trend away from the stock and have bedding altitudes across the long axis trend of the stock. These units are interpreted by the author to have been deposited in paleodepressions eroded into the flanks of the former Jubilee volcano. The metasedimentary rocks and felsic flow rocks in the Stanley Lake area are good examples of units occupying depressions within the former volcanic edifice.

Rare bedding within intermediate composition tuffs lying east and south of the stock dip at 40 to 60° away from the stock. Lying outside the intermediate composition tuffs to

the east is a partial ring of quartz-feldspar porphyry enclosing the Jubilee Stock that separates the intermediate tuffs that dip away from the stock from northeast-striking, vertically dipping supracrustal rocks. This partial ring of quartz-feldspar porphyry strikes southeast from Highway 101 to an area approximately 8 km south of the Firesand River Carbonatite. Isolated patches of quartz-feldspar porphyry occur east of Reed Lake and at Bond Lake, forming a partial ring-like enclosure to the stock. The author has suggested that the quartz-feldspar porphyry occupies a ring fracture and is part of a caldera structure centered on the Jubilee Stock (Sage 1979). While a caldera model appears appropriate for the Jubilee Stock, faults and structures that could be attributed to caldera development could not be traced north of Wawa Lake and higher into the stratigraphy. Such structures may have once existed but strike-slip or thrust faulting along Wawa Lake may have juxtaposed a stratigraphy north of the lake which was originally much more distal to the volcanism related to the Jubilee Stock.

Frohberg (1936, p.49) suggested that the Jubilee Stock was emplaced into an anticlinal structure but this could not be confirmed by the writer due to a lack of facing data. Moore (1931, p.17), Gledhill (1927, p.18) and Frohberg (1935, p.45) described the stock as consisting of cupolas, bosses, dikes and protuberances composed dominantly of diorite to granodiorite which intruded cover rocks. This description of the granitic rocks contrasts with those external granitic rocks found at Oakley Lake and farther south little xenolithic material. The author considers the Jubilee Stock as not being directly related to the external granitic rocks to the south as suggested by Frohberg (1935, p.50) since there are compositional differences. Gledhill (1927, p.19) referred to the stock as the Wawa Lake Batholith. The external granites south of the stock are of batholithic proportions and the author would restrict the term Wawa Batholith to these external granitic rocks. The external granitic rocks area of the Wawa Batholith contain unsubdivided granitic rocks of several ages.

Matheson (1932, p.49) suggested that the large northeast-trending conformable granitic mass in the Michipicoten River area south of the Jubilee Stock was intruded into a regional fold. While the distributions of this granite has undoubtedly been influenced by structure, it could not be positively established that its emplacement was controlled by folding.

The Jubilee Stock has been dated by U-Pb isotopic technique as 2745 ± 3 Ma. (Sullivan et al. 1985).

HAWK LAKE GRANITIC COMPLEX

The Hawk Lake Granitic Complex consists of massive trondhjemite to granodiorite and lies north of the Hawk Lake Fault. The intrusion contains xenoliths of volcanic rock,

however, the large massive blocks of volcanic rock that characterize the Jubilee Stock are generally absent. The main body of the intrusion is medium to coarse grained and equigranular. As the margins of the complex are approached, the rock becomes sub-porphyritic in texture and gradational into quartz porphyry and quartz-feldspar porphyry. The quartz porphyry and quartz-feldspar porphyry intrusions in Esquega Township marginal to the Hawk lake Granitic Complex are possibly appendages of the Hawk Lake Granitic Complex. These porphyritic intrusions do not extend above the discontinuous band of intermediate to felsic metavolcanic rocks of subcycle one. The porphyritic intrusions are dominantly concordant to the stratigraphy even though crosscutting relationships are common.

The interior of the complex has the appearance of being exposed at a deeper structural level than the flanks. This appearance is reflected in the porphyritic margins and local sharp crosscutting relations at the contact which contrast with the massive medium to coarse grained equigranular interior of the complex. The Hawk Lake Granitic Complex is interpreted to be exposed at a much deeper structural level than the Jubilee Stock as indicated by grain size and much lower quantity of xenolithic material. The Hawk Lake Granitic Complex has been dated by U-Pb isotopic techniques as 2888 ± 2 Ma. (Turek et al. 1984, p.460).

REVERSE FAULTING

Reverse faulting has been described in several places within the Michipicoten supracrustal rocks. Gledhill (1935, p.50) reported the presence of a reverse fault in the Darwin mine with a displacement of approximately 33 m.

At the Helen and Eleanor iron ranges, closely spaced reverse or thrust faults are present and at the Helen Iron Range they locally thin the ore (Goodwin 1962, p.566). These reverse faults are sinuous and strike east dipping at 15 to 30°S displacing the ore northward (Canadian Mining Journal 1956, p.83). At the Helen Iron Range, the contact between the banded iron formation and siderite is a flat thrust fault (Canadian Mining Journal 1956, p.85). The reverse faults are displaced east side up by north-trending cross faults (Canadian Mining Journal 1956, p.87) indicating thrusting preceded extension.

The reverse faulting at the Helen Iron Range could be due to drag folding and compressional forces related to right-lateral strike-slip or thrust movement on the Talbot Lake Fault.

The Jubilee Shear Zone and its faulted offset the Darwin Shear Zone are most likely a reverse faults. The shear dips 40 to 50°E at surface and at the 5th level of the Citidel Gold Mines Incorporated property the shear dips 30 to 35°E (Rupert 1979, p.83). The shear

strikes 20 to 25° and is subparallel to the long axis of the Jubilee Stock. In underground workings at the Citadel Gold Mines Incorporated, the shear strikes 35° at the north end of the workings and 10° at the south end (Rupert 1979, p.84). The shear pinches and swells varying from 7 to 67 m in width and the walls are not clearly defined (Rupert 1979, p.83, 84). The shear zone bifurcates and contains zones of unsheared wall rock (Rupert 1979, p.83). Pinch and swell structures within the shear have a 15 to 20° rake to the southeast (Rupert 1979, p.84). The shear gradually widens and then abruptly pinches off down dip a point at which the pinch out on the shear plunges 11° southward (Rupert 1979, p.84). The zone likely continues below the 5th level but it has not yet been investigated.

The northeast-striking Jubilee Shear Zone extends approximately 3.2 km to the southwest where it is abruptly cut off by the Parkhill Fault which is the southeastern extension of the regional Black Trout Lake transverse fault. Offset of the Jubilee Shear Zone on the Parkhill Fault is left-lateral for approximately 850 m and the shear reappears on the west side of the Parkhill Fault at Ward Lake. The shear continues to the west of the former Darwin mine property where it is known as the Darwin Shear Zone. The Darwin Shear Zone is steeply dipping at approximately 70 to 75°E and is likely at a structurally higher level of exposure than the Jubilee Shear Zone. This observation suggests that the present level of exposure along the Jubilee-Darwin shear zones is an oblique section.

Compression and resulting movement was from southeast to northwest.

Mapping by the author and unpublished detailed mapping by Studemeister (1984, personal communication, Dunraine Mines Limited) indicate the metavolcanic rocks east of the Jubilee-Darwin shear zones are of higher metamorphic rank than those to the west. The contrast does not appear sufficiently great however to be able to estimate a vertical component to the thrusting. The Jubilee Tuffs east of the Jubilee Shear Zone which are of upper greenschist facies probably represent a series of epiclastic tuffs lying between the felsic and mafic parts of cycle one volcanism. These upper greenschist facies rocks contrast with lower greenschist facies rocks of more felsic composition west of the fault which probably represent a stratigraphy higher in the stratigraphic section. The rocks west of the Jubilee Shear Zone have been dated by U-Pb isotopic techniques as 2744 ± 10 Ma. and are comparable to those exposed north of Wawa Lake lying below the Helen Iron Range (Turek et al. 1982 p.1015). The slightly higher metamorphic grade east of the shear is consistent with the higher grade rocks being thrust over lower grade rocks to the west. Moore (1931, p.15) considered mineralization along the Jubilee Shear Zone to have occurred after faulting. The shear is now represented by carbonatized sericite and chlorite schists and Rupert (1979, p.83) reported that gabbro dikes have been intruded along the thrust.

STRIKE-SLIP FAULTING

Strike-slip faulting is the oldest recognizable faulting in the area and is commonly represented by schistose metavolcanic rocks and metasedimentary rocks along formational contacts. The lack of marker horizons prevents the determination of any offset, however, bedding planes offer a preferred zone of weakness along which deformation took place. Considering the considerable amount of folding and faulting that has taken place in the Wawa supracrustal rocks major amounts of adjustment have undoubtedly taken place in a strike-slip manner and displacements on the order of kilometers are anticipated. The old strike-slip faults are cut and offset by younger transverse faults. This strike-slip period of faulting is the oldest tectonic event recognized by the author and by Massey (1985, p.52) who correlates it to a period of schistosity development and flattening.

WAWA LAKE FAULT

The Wawa Lake Fault is one of several major faults in the Wawa supracrustal rocks even though it is not exposed for study in the map area. Faulting along the south side of Wawa Lake was suggested by Gledhill (1927, p.19) who interpreted the northeast striking linear ridges on the south side of Wawa Lake that are conformable to the stratigraphy to be fault scarps. The author concurs with Gledhill that strike-slip faulting has undoubtedly influenced the development of these ridges, however, in the author's opinion the main zone of faulting passes along the axis of Wawa Lake and the scarps are minor faults subparallel to the main fault. Ministry of Natural Resources personnel in Wawa reported that Wawa Lake is in excess of 40 m deep in its deepest part and a pronounced topographic low occupied by swamp and Owens Lake (local name) extends eastward from the lake. Extending the fault east of Owens Lake is difficult for it parallels stratigraphy.

The author is of the opinion that in all probability a jog in strike takes place at the southeast corner of Wawa Lake where a cross-fault occurs in a topographic low at the east end of the lake. The Wawa Lake Fault joins with the Hawk Lake fault and continues to the northeast for many kilometres. Considering that high ridges occur on both sides of Wawa Lake along with the deep water in the lake; the fault occupies a major topographic depression in the bedrock.

The Wawa Lake, Hawk Lake and Manitowik Lake faults represent the same zone of faulting along strike and trend approximately 60° and Goodwin (1964, p.566) has proposed that the south side moved east relative to the north side along this zone of faulting. The presence of reverse faulting south of Wawa Lake (Jubilee Shear Zone) and inverted

stratigraphy in Chabanel Township (rocks face west, dip east) in the north is consistent with compression from southeast to northwest. It is likely the movement is southside east with respect to the north side which is consistent with the movement suggested by Goodwin (1964).

At the jog in the Wawa Lake Fault, at the east end of Wawa Lake, where it joins the Hawk Lake Fault the northeast-striking Wawa-Hawk Lake Faults are joined by the transverse Firesand River Fault. The Firesand River Carbonatite occurs immediately southwest of this fault junction and it is likely that tectonic reactivation of these faults in middle Proterozoic created a point of stress relief at this fault junction that controlled carbonatite emplacement. Carbonatites are of mantle origin (Wyllie and Huang 1976). The presence of a carbonatite at this location implies that the associated Wawa and Hawk Lake faults have roots in the mantle.

Rupert (1979, p.49) suggested the possibility of a fault in Wawa Lake and the author concurs with this interpretation. The author and Rupert (1979, p.49) have observed that Wawa Lake separates two entirely different structural domains of supracrustal rocks:

- A. North of Wawa Lake a monoclinical north-facing northeast-striking succession of overturned volcanic rocks dips steeply south. On the south side of the lake secondary structures west of the Jubilee-Darwin shear zones dip at low angles to the south.
- B. The pervasive soaking of carbonate that characterizes the metavolcanic rocks north of Wawa Lake all the way to Goudreau is absent south of the Lake. Carbonate alteration south of the lake is restricted to shear zones, joints and fractures.
- C. North of Wawa Lake lamprophyre dikes are uncommon and even rare. South of Wawa Lake lamprophyres are abundant.
- D. Northwest-trending mafic dikes referred to as older diabase by Collins and Quirke (1926, p.37) and Matheson (1932, p.51-54, 1933, p.8-9) are either absent north of Wawa Lake or equivalent intrusions have not taken on such a pronounced dike-like form.
- E. Major transverse faults, such as the Wallbank Lake, Mildred Lake and Bauldry Lake Faults cannot be found south of Wawa Lake or can the Jubilee Shear Zone (reverse fault) be traced north across the lake.

Rupert (1979, p.50-51) considered the rocks south of Wawa Lake to be younger than rocks north of the lake and interpreted his data to indicate no systematic structural pattern exists south of the lake. The author has found that a structural pattern does exist south of the lake but that it is nowhere as clearly defined as north of the lake. Lithologic correlations across the lake are difficult or impossible. Uranium-lead isotopic ages completed

by Turek (1982, p.1615-1621) indicate, however, that the rocks north and south of the lake are similar in age and are likely part of the same stratigraphic package or volcanic cycle.

The author correlates the Wawa Lake Fault with the Hawk Lake Fault which in turn correlates with the Manitowik Lake Fault. Together this is a major regional fault which the author considers related to major northeast-faulting associated with the Kapuskasing Structural Zone. Massey (1985, p.56) correlated his Driftwood Fault with the Wawa Lake Fault. The Driftwood Fault is poorly exposed in the adjacent area (Massey 1985). In the Manitowik Lake area left-lateral movement on the fault suggests an offset of approximately 2.8 km (Goodwin 1963).

HAWK LAKE FAULT

Evidence for the Hawk Lake Fault is not as strong as for the Wawa Lake Fault. The presence of a fault along the lake is inferred by the linear topographically high ridge on the north side of the proposed fault. The high linear hills north of Hawk Lake are likely fault scarps that strike subparallel to the main zone of faulting. Between the south end of Hawk Lake and the Firesand River, the contact between the supracrustal rocks and granitic rocks appears abrupt even though data is meagre due to sand plain cover. Shearing conformable with the proposed fault trend is common in the supracrustal rocks exposed to the north of the sand plain. Towards the east, the Hawk Lake Fault may be offset to the north by one or both of the transverse Marsden or McVeigh Creek faults. Mixed rocks characteristic of migmatitic terrain occur immediately south of the railway station at Hawk Junction and massive equigranular granitic rocks, characteristic of the Hawk Lake Granitic Complex occur farther north. Left-lateral offset of several kilometres by transverse faulting is anticipated.

TALBOT LAKE FAULT

North of the Helen Iron Range, a very prominent fault separates the overturned, north-facing, monoclinical sequence containing the Helen Iron Range from an anticlinal structure to the north. The fault enters the map area from the west beneath sand cover and forms an "S" shaped curve outlined by Talbot Lake. At the north end of Talbot Lake, the fault zone is narrow (20 to 40 m wide), strikes east, appears to be subvertical in dip and continues in a straight line to Wallbank Lake. At Wallbank Lake the fault intersects the transverse Wallbank Lake Fault and even though such a pronounced fault likely continues to the east it could not be traced. The Wallbank Lake Fault has a left-lateral offset of approximately 600 m (Moore and Armstrong 1946, p.79) so this fault should continue east

from the Wallbank Lake Fault at a point approximately 600 m north from where it strikes the fault from the west.

At Talbot Lake, the metavolcanic rocks and iron formation to the east of the fault underwent considerable drag. Northeast-trending bedding has been bent around and strikes approximately due north at the west end of the Helen Iron Range. The direction of movement is south side west and is likely a product of compression from the southeast consistent with observed patterns of thrust faulting in the area. The proposed direction of movement is in agreement with that proposed by Goodwin (1964, p.566). Stretched clasts, spherulites and fold axes in the drag-folded metavolcanic rocks and iron formation all plunge east at 50 to 60°. This plunge is also consistent with the easterly plunge of siderite ore bodies within the Helen Iron Formation (Canadian Mining Journal 1956, p.86). Folding in the iron formation becomes more intense to the west towards the Talbot Lake Fault and to date no other iron formation in Wawa has displayed such pervasive folding. The restriction of folded iron formation to the west end of the Helen Iron Range, its absence in other Michipicoten Iron Ranges and the consistent orientation of fold-axes plunging to the east are more characteristic of tectonic activity than primary slump at the time of deposition (Plate 37).

FAULTING WITHIN THE HELEN IRON RANGE

Structures within the Helen Iron Range, even though minor in comparison to larger regional structures, are important, relative to the Talbot Lake Fault. The author is of the opinion that movement on the Talbot Lake Fault has had a major influence in structurally upgrading the iron formation to form ore bodies.

Goodwin (1964, p.687) has interpreted the rocks of the Helen Iron Formation to be either folded about an east-west syncline or to occur on a south limb of a syncline. Mapping by the author has not established such a structural position. Moore and Armstrong (1946, p.103) proposed that the Helen Iron Range, at the immediate mine site, is a tightly compressed anticline, however, the author has found no evidence for such folding in the eastern, less deformed portions of the iron formation. The unit consistently faces north conformable with stratigraphy and is monoclinal.

The most detailed structural study of the Helen Iron Range is the report of Canadian Mining Journal (1956). Faulting of the Helen Iron Range was subdivided by them into five groups (Canadian Mining Journal 1956, p.86, 87). These groups are as follows:

1. East-type Faults

These faults strike 60° and dip approximately 60° to the northwest to southeast. The faults have a left-lateral movement and are confined to the Victoria Orebody located in the centre of the iron range. These faults merge with flat-lying thrust faults.

2. Valley-Type Faults

These faults strike 090 to 120° and dip steeply south. Movement is right-lateral, horizontal and produces breccia. This faulting is restricted to the Victoria Orebody.

3. Transverse Faults

These faults strike 35° and dip steeply east and west. The faults have left-lateral movement up to 80 m and horizontal displacement. A strong footwall displacement may not be apparent on the hanging wall (mining hanging wall). These faults may be discontinuous and are largely confined to the upper levels of the Helen Iron Range.

4. Victoria-Type Faults

These faults strike northwest and dip steeply southwest to northeast. They have left-lateral movement consistent with regional patterns and are commonly intruded with diabase dikes. They displace flat thrust faults upwards on the east side. Kidder and McCartney (1946, p.22), however, reported offset is east side down. Kidder and McCartney (1946, p.22) reported offset on these faults to be on the order of a few to 33 m. The two-northwest trending dikes in the Victoria part of the Helen Iron Range occupy faults that offset the lower south contact approximately 166 m and the north contact 33 m. Tanton (1948, p.427) attributed this difference in offset of the upper and lower contacts to a vertical component of movement of undetermined magnitude.

5. Flat Thrust Faults

These faults strike east and dip 15 to 30°S . Due to their flat nature appear sinuous in plan view.

Tanton (1948, p.427) described north-to northeast-striking faulting at intervals of 50 to 83 m in the western part of the Helen Iron Range. The faults are subvertical and have their east side offset to the north consistent with the regional pattern. Canadian Mining Journal (1956, p.87) reported that as mining reaches greater depths faulting decreases. They also reported that faulting in one lithologic unit may be missing in adjacent units implying control by rock competency. Transverse faulting in the western part of the Helen Iron Range is reported by Kidder and McCartney (1946, p.22) to curve around above and below the iron formation and follow the stratigraphy. These faults are reported to be subvertical in dip. Moore and Armstrong (1946, p.104) observed that the iron formation is extensively brecciated between the former Sayer Lake (drained) and Talbot Lake. Some of this brecciation is clearly tectonic however a large part is also primary, formed at the time of iron formation

deposition. Goodwin (1964, p.706) proposed that the Helen Iron Range was tilted to the east at approximately 35° after folding about a east-west axis, faulted by low angle south-dipping thrusts and then by high angle transverse faults. He based the angle of tilting on contoured geochemistry which could not be confirmed by the author. The ore zones plunge east at a much steeper angle (50 to 60°) than the suggested angle of tilting by Goodwin (1964, p.706) (Canadian Mining Journal 1956, p.86).

The eastern end of the Helen Iron Range towards the Wallbank Lake Fault is on the order of 23 to 46 m in thickness (Moore and Armstrong 1946, p.95). The western end of the Helen Iron Range exceeds 333 m in thickness of which more than 66 m may be siderite (Moore and Armstrong 1946, p.95). Goodwin (1962, p.577) reported that the carbonate member at the western end of the Helen Iron Range to be up to 116 m thick and that it may be up to 66 m thick at Eleanor, Lucy, Ruth, Josephine and Bartlett iron ranges. Mining operations at the Eleanor and Lucy iron ranges have exposed the carbonate member and widths of 33 m are indicated. Goodwin (1962, p.577) reported that locally the carbonate member is absent. Mapping by the author at the Eleanor, Lucy and Ruth iron ranges, indicate that the Michipicoten iron formation ranges between 100 and 133 m thick even though thinner and thicker sections can be locally found. The thickening and thinning of the iron formation appears to be related in most instances to faulting. Goodwin (1962, p.574) correlated the Mildred, Helen, Johnson, Eleanor, Lucy, Ruth, Josephine-Bartlett and East Brooks Ranges, however, Richter (1952, p.33) considers the Mildred Iron Range to be unrelated to the Helen. The author concurs with Goodwin on the correlation with the exception of East Brooks where mapping and interpretation are presently incomplete. Goodwin (1964, p.687) interpreted the Mildred Iron Range to be on the north limb of a drag folded anticline (referred to as the Lagarde Lake Anticline) and mapping has disclosed a maximum width of 83 m of iron formation. This iron formation is generally much thinner than the other iron ranges. The thickness of the iron formation is highly variable between the Mildred (less than 83 m), Helen (333 m west end, 100 to 133 m east end) and Eleanor, Lucy and Ruth iron ranges (100 to 133 m). The relatively thin Mildred Iron Range was likely due to attenuation during folding accompanying movement along the Talbot Lake Fault. The unusually thick iron formation at the west end of the Helen Iron Formation is likely due to compression resulting from drag movement along the Talbot Lake Fault. The Mildred and Helen iron ranges were most probably originally of a width similar to that presently exposed at the Eleanor, Lucy and Ruth iron ranges. The amount of thickening is on the order of 2 to 3 times the original thickness and the lithologic repetition in the western part of the Helen Iron Range and its absence in the other iron ranges may be the result of stacking due to tectonism. Therefore, the present lithologic distribution may not be

a primary depositional feature which would complicate modeling as presented by Goodwin et al. (1985).

MAGPIE RIVER FAULT

The Magpie River Fault occupies a prominent depression in bedrock topography and is covered by flat lying gravel terraces that flank the river. The Magpie River Fault is not exposed and its presence is inferred by sheared rock and contrasting rock structural attitudes north and south of the fault. The fault is subparallel to the Wawa Lake and Talbot Lake faults and consists of a broad zone of shearing and faulting rather than discrete fault line.

The Magpie River Fault enters the map area from the west along the bed of the Magpie River and the metasedimentary rocks north and south of the river locally display prominent shearing and minor tight folding. Along this part of its strike length, the fault is conformable to stratigraphy. Approximately 4.3 km from the west side of the map area, in central Chabanel Township, the Magpie River bends sharply north to Steep Hill Falls; the fault, however, continues eastward beneath gravel and sand deposits to Mildred Lake. At Mildred Lake, the fault is cut off and offset to the north by the transverse Mildred Lake Fault. As the fault extends east from the bend of the Magpie River to Mildred Lake, it separates northwest-facing, northeast-striking, subvertically dipping clastic metasedimentary rocks to the south from overturned southwest-facing, northeast-dipping, southeast-striking intermediate to mafic metavolcanic rocks to the north. As Mildred Lake is approached, the fault trace becomes sinuous and is partially exposed north of the sand and gravel deposits where outcrops of metasedimentary rocks and metavolcanic rocks occur in close proximity to each other. At the Mildred Lake Fault, the east extension of the Magpie River Fault is offset approximately 2666 m north. The extension of the fault lies north of the Lucy Iron Range separating southeast-striking overturned metavolcanic rocks to the north from northeast-striking subvertical clastic metasedimentary rocks to the south. A subparallel fault extends eastward from the east-striking north arm of Mildred Lake and occupies a prominent topographic depression to Bauldry Lake. The main fault appears to intersect Bauldry Lake in a small west-trending bay on the west side of Bauldry Lake. At this position, the main fault is internal to the clastic metasedimentary rocks and a minor, poorly defined branch of the fault continues northeast and then bends east to Bauldry Lake. This branch separates the southwest-striking recumbent metavolcanic rocks from the northeast striking metasedimentary rocks. This branch from the main fault bounds a small isolated block of north-facing clastic metasedimentary rocks lying between the main fault trend and the branch fault. Primary structures within the metasedimentary rocks indicate both north and south

facing directions suggesting to the author that numerous minor folds have been superimposed on the metasedimentary rocks. North facing determinations are dominant. The subsidiary fault extending east from Mildred Lake to Bauldry Lake results in stacking of the north-facing clastic metasedimentary rocks. The metasedimentary rocks between the main fault and the subsidiary fault to the south are a repetition of the metasedimentary rocks south of the subsidiary fault that lie above the underlying metavolcanic rocks of cycle two.

The Bauldry Lake Fault offsets the Magpie River Fault to the north approximately 600 m.

The most northerly subsidiary fault is offset to the north approximately 800 m. The Magpie River Fault continues northeast beneath Goetz Lake. Northeast of Goetz Lake, the precise location of this branch of the Magpie River Fault is obscure and could be represented by any number of lineaments. In general, it occurs at a position separating the northeast-striking clastic metasedimentary rocks from southeast-striking recumbent metavolcanic rocks passing through the Parks Lake area and above the Josephine-Barlett iron ranges.

The main Magpie River Fault most likely extends northeast through the south part of Goetz Lake to Josephine Creek.

The southern subsidiary to the main fault cuts across the clastic metasedimentary rocks and continues down through the intermediate to mafic metavolcanic rocks. Approximately 1000 m of metavolcanic rocks west of the Bauldry Lake Fault are represented by 500 m east of the fault and this is reduced to zero 1000 m east of the fault. At this point, the metasedimentary rocks have been faulted down onto the Ruth Iron Formation. The rocks on the north side of Cuthbertson Lake are extensively brecciated by this faulting. The subsidiary fault continues along the top of the Ruth Iron Range to the Goetz Lake Fault where it is offset to the north. This southern branch of the Magpie River Fault joins with the main fault at Josephine Creek. The main Magpie River Fault passes beneath Parks Lake and with minor offsets continues northeast. The main fault now separates north-facing clastic metasedimentary rocks from north-facing iron formation of the Josephine-Bartlett Iron Range. Minor slivers of intermediate to mafic metavolcanic rocks occur above the iron formation at the southwest and northeast ends of Parks Lake (Corbiere Township). East of Parks Lake, the fault separates south-facing clastic metasedimentary rocks and metavolcanic rocks from north-facing iron formation and is represented by a prominent topographic linear. The Magpie River Fault bends from northeast to southeast and intersects the transverse Marsden Fault to the east. The Marsden Fault offsets the Magpie River Fault to the north, but its position east of the fault is presently uncertain.

The Magpie River Fault and its subsidiaries are of petrologic interest. At Lena Lake, Mildred Lake, Bauldry Lake and at the east end of Endless Lake (immediately north of Parks Lake, Corbiere Township), peridotite intrusions are present. These intrusions occur in proximity to the intersection of the Magpie River Fault and transverse faults. Since the transverse faults are post-folding and post-strike-slip or thrust faulting, these mafic intrusions are likely younger than the supracrustal rocks.

To the west of the map area, Massey (1985, p.56) correlated his Brient Fault with the Magpie River Fault.

JOHNSON IRON RANGE FAULT

The Johnson Iron Range pinches and swells and appears to be of narrower width than its western extension (Helen Iron Range) and its eastern extension (Eleanor and Lucy Iron Ranges). Critical exposure to establish strike-slip faulting is lacking, however, the author considers it highly likely that strike-slip faulting has occurred in proximity to or within this iron range to account for its pinch and swell nature.

North of the Johnson Iron Range, shearing and possible strike-slip faulting occurred at or close to the metasedimentary-metavolcanic contacts just south of Arliss Lake. A series of distinctive quartz feldspar porphyries with quartz phenocrysts up to 1 cm occur in or close to this suggested shear zone.

LOONSKIN LAKE FAULT

The rocks along the axis of Loonskin Lake often display a strong fissile nature and some brecciation. The deformation can make recognition of primary textures difficult and the determination of facing directions impossible. The lack of marker horizons across Loonskin Lake prevents any determination of degree or magnitude of movement but the author expects that it was major. The Loonskin Lake Fault is subparallel to lithologic trends and occurs just above subcycle one. The southern extension of this proposed fault merges with the transverse Bauldry Lake Fault and its northern extension is represented by a series of lakes and topographic lows that strike northeast from the north end of Loonskin Lake beyond which it bends south and becomes east striking subparallel to the Algoma Central Railway line along the northern edge of Esquega Township. The east-striking eastern extension goes from a prominent topographic depression into a region covered by a sand plain north of Hawk Junction. The fault likely intersects the transverse Marsden Fault and it is likely displaced northward by this fault.

TRANSVERSE FAULTS

Transverse faults cut reverse faults, strike-slip faults, and fold structures. These faults display little evidence of post-formation folding and invariably exhibit left-lateral strike slip movement. Moving east from the Wawa supracrustal belt towards the Kapuskasing Structural Zone studies of metamorphic assemblages suggests that one is looking at an oblique section through the crust and at ever deeper structural levels (Percival 1983; Percival and Card 1983, p.323; Cook 1985, p.368). The author concurs with this suggestion of Percival (1983) and as a consequence would suspect that vertical offset on the transverse faults would be consistently east side up. The lack of marker horizons and petrologic evidence establishing contrasting metamorphic facies across the transverse faults prevent any determination of the magnitude of this possible vertical movement. Most transverse faults are northwest-striking, however, the Firesand River Fault strikes northeast. The northwest-trending transverse faults are characterized by ever decreasing amounts of left-lateral displacement as one moves northward. This feature was also observed by Goodwin and he has also postulated that the west side is structurally lower than the east side (1962 p.566). Goodwin (1962, p.566) proposed that this variable degree of offset is the result of a scissors (hinge) movement on the transverse faults and the author concurs. In this model the southern end of a transverse fault likely has greater vertical displacement than the northern portion. The northwest-trending transverse fault set is often occupied by diabase dikes. In the area south of Wawa Lake, linear northwest-trending mafic intrusions occupy faults or shears and have been intruded by younger diabase. These intrusions are interpreted to be Archean in age suggesting that the northwest-trending transverse faults are following an old fracture pattern. This period of transverse faulting probably correlates with Massey's (1985, p.53) second period of deformation and his third period correlates with the author's period of fault reactivation and diabase emplacement.

FIRESAND RIVER FAULT

The presence of a fault along the Firesand River beneath sand and gravel cover is based on the recognition of a contrast in structural attitudes east and west of the proposed fault. The presence of this inferred fault was suggested by Rupert (1975). Rocks east of the fault, strike west of north and those west of the fault strike north of east indicating an inflection in lithologic trends. The proposed fault is represented by a sand and gravel filled topographic low in the bedrock surface. The Firesand River Fault terminates at its northeast

end in the area of the short cross-fault that joins the strike-slip Wawa Lake and Hawk Lake Faults. Its southern termination appears to be at a point of intersection with the southeastern extension of the Parkhill Fault (N. Massey, Ontario Geological Survey, personal communication, 1984). The junction of the Wawa Lake - Hawk Lake Faults and transverse Firesand River Fault may have been the controlling structural influence for the emplacement of the Firesand River Carbonatite which occurs at the northeast end of this fault near its junction with the Wawa Lake and Hawk Lake faults.

PARKHILL FAULT

The Parkhill Fault is the southeastern extension of the northwest-striking Black Trout Lake Fault (Goodwin 1963). The Parkhill Fault offsets a reverse fault, the eastern portion is known as the Jubilee Shear Zone and the west portion is known as the Darwin Shear Zone. The fault offsets the contact between the Jubilee Stock and the enclosing metavolcanic rocks. Left-lateral offset on the Jubilee-Darwin shear zone is approximately 800 m (Sage et al. 1982b).

The Jubilee Shear Zone dips 45°E at the surface and 30 to 35°E at the 5th level of the Citidel Gold Mines Incorporated property (Rupert 1979, p.83). The Darwin Shear Zone dips subvertical to 70°E . Since reverse faults may approach subvertical dips at higher structural levels the shallower dips on the Jubilee Shear Zone than on the Darwin Shear Zone may indicate that the Jubilee Shear Zone represents a deeper level of exposure than the Darwin Shear Zone. Deeper level exposure on the Jubilee Shear Zone suggests that displacement at the north end of this reverse fault is greater than that at the south end and that the present erosional level represents an oblique section through this fault zone. The fault plane of the reverse fault is tilted southwest as suggested by Rupert (1979). The greenschist (west) and contrasting upper greenschist (east) metamorphism across the Jubilee-Darwin shear zones appear to disappear to the south which also indicates a southwest tilt to the fault zone and an oblique section through it. The Parkhill Fault is occupied by mafic intrusive rocks interpreted to be Archean in age and much younger possibly Proterozoic diabase. The fault has been active several times during geologic history.

WALLBANK LAKE FAULT

A northwest-striking (330°) fault extends from the north side of Wawa Lake northwest through Wallbank Lake and continues northward to the proximity of the Magpie River where

it becomes difficult to trace. The fault could not be convincingly traced south of Wawa Lake even though sheared rock exists in several places on the south shore of the lake.

Offset along the fault is left-lateral. The fault separates the Helen Iron Range from the Johnson Iron Range and has a strike-slip offset of approximately 600 m (Moore and Armstrong 1946, p.104). No estimate of the vertical component of movement could be made. The fault is occupied by a diabase dike classified as a quartz diabase by Moore and Armstrong (1946, p.104).

MILDRED LAKE FAULT

The northwest-striking (330°) Mildred Lake Fault is perhaps one of the most pronounced transverse faults in the project area. The fault splits into three branches within Lena Lake with the main branch striking 143° southeast where it merges with the Bauldry Lake Fault. This branch separates mafic metavolcanic rocks of cycle two that overlie the Eleanor Iron Range from cycle one mafic metavolcanic rocks that form the footwall to the Lucy Iron Range. This branch of the Mildred Lake Fault is reported by Moore and Armstrong (1946, p.85) to be occupied by a quartz diabase dike, however, only one possible outcrop of this dike could be located during the present survey. The west branch of the Mildred Lake Fault continues south from Mildred Lake and is represented by a prominent topographic depression at the south end of the lake. This branch of the Mildred Lake Fault is now covered by mine waste from the Sir James pit located in the Eleanor Iron Range. This fault separates the Johnson Iron Range to the west from the Eleanor Iron Range to the east. Moore and Armstrong (1946, p.85) reported the west branch of the fault trends at 165° towards Wawa Lake and a split from this branch fault trends at 200°. Offset on both the branch fault and the split is 200 m (Moore and Armstrong 1946, p.85). Movement on the branch fault and the split from the branch is left-lateral and the reader should refer to Moore and Armstrong (1946, p.83, Figure 13) for a diagram showing the pattern of faulting found by them at the west end of the Eleanor Iron Range.

North of Lena Lake, the Mildred Lake Fault is easily traced along a series of elongated lakes and topographic depressions. Within that part of the Mildred Lake Fault transverse to lithologic strike the fault is easy to trace. North of Mildred Lake and continuing northwest through Musquash Township the fault appears to be strike-slip and lies parallel to the stratigraphy of the recumbent south limb of the Centre Anticline recognized by Goodwin (1963). The trace of the fault in this area is largely based on topography, the fault zone being bounded by steep linear ridges of outcrop. Left-lateral offset on the Mildred Lake Fault on the basis of iron formation separation is approximately 3533 m (Sage et al.

1982b). As one moves east, one may be examining ever deeper structural levels within the supracrustal rocks (Percival 1983), therefore, the east side of the Mildred Lake Fault may be up relative to the west side.

As a result of faulting, the Eleanor Iron Range lies within a wedge-shaped fault bounded block consisting of a north-facing stratigraphic succession. The south boundary of this block is the Wawa Lake Fault, the east boundary the Bauldry Lake Fault, the north boundary the main branch of the Mildred Lake Fault and the west boundary the subsidiary branch of the Mildred Lake Fault.

Neither the Mildred Lake or Bauldry Lake faults could be traced south of the Wawa Lake Fault nor recognized along their extrapolated extension.

BAULDRY LAKE FAULT

The Bauldry Lake Fault strikes north, occurs in proximity to the Chabanel-Esquega Township boundary and is represented by a prominent topographic north-striking linear and a series of linear lakes. The fault separates the west end of the Ruth Iron Range from the east end of the Lucy Iron Range. Offset is left-lateral and is approximately 600 m (Sage et al. 1982c). At the north end of Bauldry Lake the rocks along the fault zone are well exposed and are extensively brecciated. The Bauldry Lake Fault is composed of at least two closely spaced parallel zones of faulting. Both the western and eastern end of the Lucy Iron Range appear to be dragged up or down in keeping with the direction of movement implied by offset on the Mildred and Bauldry Lakes faults. Young (1951, p.35) considered the minor faults within the Lucy Iron Range to be related to drag along the Mildred Lake Fault. Moore and Armstrong (1946, p.79) indicated a left-lateral offset of approximately 2100 feet and Richter (1952, p.35) suggested 1050 feet of offset.

GOETZ LAKE FAULT

The Goetz Lake Fault was formerly named the Josephine Fault by Goodwin (1963), however, the author prefers the name Goetz Lake since the fault passes along the northeast side of Goetz Lake. The author uses the name Josephine Fault to apply to a fault that passes through the Josephine iron mine on the east side of Parks Lake, Corbiere Township.

The Goetz Lake Fault separates the east end of the Ruth Iron Range from the west end of the Josephine Iron Range. Offset is left-lateral and approximately 833 m (Sage et al. 1983c). Moore and Armstrong (1946, p.79) reported a left-lateral offset of approximately 2600 feet and Richter (1952, p.37) suggested 3300 feet of offset. The fault zone is occupied by

two or more diabase dikes which underwent up to 266 m of offset as the result of post-emplacement strike-slip movement along lithologic contacts at the west end of the Josephine Iron Range, Corbiere Township. The Goetz Lake Fault trends 330° and due to the presence of diabase dikes it does not form as prominent a topographic low as those faults not occupied by diabase. The Bauldry Lake Fault joins with the Goetz Lake Fault at the west end of Andre Lake, Musquash Township. The Bauldry-Goetz Lake Faults have a northwest trend from West Andre Lake that is parallel to lithologic trends on the recumbent south limb of the Centre Anticline. This trend is represented by diabase dikes and linear topographic features.

The Goetz Lake Fault strikes southeast to Loonskin Lake where it may be cut off by strike slip-faulting along Loonskin Lake. If this fault continues southeast of Loonskin Lake it likely passes along the stream-lake system draining McEwen Lake. A northwest-trending topographic linear north of Bremner Lake passing through or near the Bukell Copper showing may also be representative of a southeastern extension of this fault. The Ruth Iron Range lies within a north facing, subvertically dipping, fault bounded wedge-shaped block. The west boundary is the Bauldry Lake Fault the north and east boundary the Goetz Lake Fault and the south boundary is the strike-slip Loonskin Lake Fault.

In Corbiere Township, along the east side of Parks Lake a north-trending left-lateral fault, probably joins with the Goetz Lake Fault near the northern boundary of Esquega Township. Offset on this fault is minor, on the order of 25 m. The author refers to this fault as the Josephine Fault and Moore and Armstrong (1946, p.51) referred to the fault as the Morrison Fault. The fault continues north to at least Endless Lake where Moore and Armstrong (1946, p.51) reported an offset of 20 m. Moore and Armstrong (1946, p.50, 51) reported that the fault strikes 355° , dips 85 to 90° W, displays gouge along the fault and at the Josephine iron mine it is pre-ore origin.

MARSDEN FAULT

The extrapolated southern extension of the Marsden Fault is interpreted to be beneath sand cover in the northeast corner of Esquega Township. This fault will be discussed in a following report.

MCVEIGH CREEK FAULT

Within the present limits of the four townships, this fault is poorly exposed. It is present in the extreme northeast corner of Esquega Township where it is represented by a

high linear ridge of granitic rock. This fault strikes north and is occupied by McVeigh Creek and a series of linear lakes. This fault is discussed by Sage (1987b).

FOLDING

The present project covers only four of many townships covering parts of the Wawa supracrustal sequence. As a consequence, major regional fold patterns cannot be completely resolved.

Folding and lithologic facing directions could not be resolved south of Wawa Lake at the time of mapping. The rocks in this part of the map area lacked exposed primary textural and structural features that could be used to unravel possible folding in the area. Froberg (1935, p.49) suggested that the Jubilee Stock has been emplaced into an anticlinal structure, however, the lack of facing data prevents confirming this interpretation.

Goodwin (1962, p.564) proposed that the Wawa supracrustal rocks have been folded about an east-west cylindrical axis and then cross folded about a northwest-trending axis producing the undulatory lithologic distribution. He proposed three east-west fold axes, North Range Syncline, Centre Anticline and South Range Syncline, of which the South Range Syncline is the only major east-west fold lying more or less completely within the present project area.

Goodwin (1962, p.565) proposed that three main cross folds occur within the Wawa supracrustal rocks; these are the Dore Anticline, Kabenung-Josephine Cross Anticline and Goudreau Cross Anticline. None of these cross folds lie totally within the present project area.

SOUTH RANGE SYNCLINE

Goodwin (1962, p.565) proposed that the axis of this syncline starts at Michipicoten Harbour and extends eastward across to Manitowik Lake with northwest-striking cross faults offsetting the fold axis. He described the axial plane as overturned to the north up to the Mildred Lake Fault and upright further to the east. Facing attitudes establishes the presence of this fold in the Michipicoten Harbour area (Massey 1985, p.54), however, it could not be traced eastward to the west boundary of the map area. Massey (1985) refers to this fold as the Dore Syncline. Goodwin (1963) placed the fold axis along the Magpie River Fault, which is a strike-slip fault at the west boundary of the map area and a sharply crosscutting transverse fault between Mildred Lake and the sharp bend in the Magpie River in the centre of Chabanel Township. Evidence for this fold could not be found within the project area.

A south-facing limb for this syncline could not be established and the north-facing stratigraphic succession is terminated by faulting. Goodwin (1962, p.565) and Goodwin and Shklanka (1967, p.791) have interpreted the intermediate to felsic metavolcanic rocks north and south of the Magpie River to be the opposing limbs of a folded volcanic sequence. Uranium-lead isotopic dating by Turek et al.(1982 1984) indicated that these intermediate to felsic rocks are separated by approximately 50 million years and therefore are not correlative across a simple fold axis.

CENTRE ANTICLINE

The axis of the Centre Anticline strikes northwest and lies in Leclaire Township north of the present project area (Goodwin 1962, p.566, 1963). This fold is discussed in Sage (1987b).

NORTH RANGE SYNCLINE

The axis of this proposed fold lies in the northern part of Leclaire Township (Goodwin 1962, p.564, 1963). The fold axis lies outside the present project area.

KABENUNG - JOSEPHINE CROSS FOLD

Goodwin (1962, p.565, 1963) interpreted this fold to be an overturned syncline whose fold axis strikes southeast from Kabenung Lake to the Josephine area. The fold axis enters the present project area in the northwest corner of Esquega Township. In the Josephine-Hawk Junction area, a gentle warp in the supracrustal-granite contact does occur, however, the author would not put a fold axis along the axis of this gentle warp. Northwest from Josephine, along the proposed axis of the fold the rocks are a recumbent monoclinial sequence facing southwest and dipping northeast. A reversal in facing directions could not be found and the existence of this fold could not be established

DORE CROSS FOLD

Goodwin (1962, p.565, 1963) interpreted this fold to be an anticline. The trace of the fold axis strikes southeast and lies west of the map area. The southern extension of this proposed fold would pass through McMurray Township. No evidence for this fold could be found.

CATFISH LAKE ANTICLINE

Goodwin (1962, p.566, 1963) indicated the presence of an anticlinal structure whose axis passes through the centre of Catfish Lake and through the northern part of Chabanel Township. He considered this proposed fold to be ancillary to the Centre Anticline. On the basis of lithologic trends and facing directions, no evidence for this fold could be found within the project area. A small anticlinal structure occurs east of the west boundary of Chabanel Township and north of the Magpie River. This small fold structure is likely a drag fold related to movement along the Magpie River Fault.

LAGARDE LAKE ANTICLINE

Northwest of the Helen Iron Range, a large expanse of intermediate to felsic metavolcanic rocks intruded by mafic intrusive rocks is present. A lack of facing directions within these rocks prevents a rigorous structural interpretation. The author considered these rocks to represent an anticlinal structure and Goodwin (1964, p.687) was the first to recognize this possible fold structure. He did not report primary structures in the metavolcanic rocks suitable to determine facing directions and positively establishing the anticlinal structure. Lineations, principally clast elongations, plunge east and presumably the fold axis also plunges east. Goodwin (1964) suggested an easterly plunge. The horseshoe-shaped mafic intrusion, open to the west, centred on Lagarde Lake roughly outlines the fold nose. The fold pinches out northwest of Wallbank Lake and cannot be traced farther east. The long linear mafic intrusions within the intermediate to felsic metavolcanic rocks appear sheared and attenuated, particularly along contacts; and the enclosing metavolcanic rocks display a well developed schistosity. The iron formation composing the Mildred Iron Range and mafic metavolcanic rocks along the proposed north limb of the fold pinch and swell and appear attenuated. Facing directions in the metasedimentary rocks immediately above the mafic metavolcanic rocks are opposing and tight isoclinal folding is present in the pebble conglomerates and wackes above the mafic metavolcanic rocks. North of the mafic metavolcanic-metasedimentary contact, grain gradations indicate a dominantly south-facing sequence consistent with that exposed north of the Magpie River. The metasedimentary rocks may be repeated and consist of numerous fault-bounded south-facing slices. On the basis of stratigraphy, the metasedimentary rocks most likely face north and the south facing rocks are likely the result of folding.

As a result of this folding, the author and Goodwin (1964, p.687) correlate the Mildred Iron Range with a western extension of the Helen Iron Range. This fold cannot be positively traced west into adjacent townships. The intermediate to felsic rocks within this fold are therefore first cycle metavolcanic rocks that have been folded and faulted above second cycle mafic metavolcanic rocks that overlie the Helen Iron Range. The south boundary of this fold is the Talbot Lake Fault and the north boundary is the Magpie River Fault.

MINOR FOLDS

North of the Magpie River, on the west side of Chabanel Township, a minor fold is present in the felsic metavolcanic rocks and metasedimentary rocks. The northwest limb lacks facing data to support its presence but the south limb is well documented. Primary sedimentary structures indicate the south limb of this proposed fold faces south. This minor fold is interpreted to be an anticline, possibly a drag fold related to movement along the Magpie River Fault. The positioning of this fold axis is uncertain.

DEFORMATION OF IRON FORMATION

The iron formation, particularly the chert portion, is resistant to weathering. Consequently the iron formation forms topographic ridges within the Wawa supracrustal rocks. The unit is competent and has behaved in a more rigid fashion than the enclosing metavolcanic rocks, particularly the footwall metavolcanic rocks. The iron formation has been cross faulted, however, most deformation probably took place during the early period of strike-slip faulting and folding. Strike-slip shearing occurs along the upper contact of the iron formation with cycle two metavolcanic rocks but it is much less pervasive than that found in the underlying fragmental rocks. A sheared upper contact is present at the Helen Iron Range, however, the only other exposed upper contact, at the Eleanor Iron Range, is not sheared. The overlying massive and pillowed metavolcanic rocks display little evidence of deformation.

The footwall tuffs are fissile, display stretched fragments, appear highly deformed and are well exposed at the Helen, Eleanor and Lucy Iron ranges. The Eleanor Iron Range is the best location to examine the strongly contrasting degree of deformation between hanging wall and footwall since mining operations in the Sir James pit have exposed both upper and lower contacts. During folding and strike-slip faulting in proximity to iron formation, most movement has taken place in the stratigraphic footwall tuffs and breccias. This dominantly

strike-slip movement most likely accounts for the pinch and swell characteristics of the siderite facies iron formation at the base of the iron formation. Minor transverse faults cut all the iron ranges.

TECTONIC MODEL

Mapping of only four townships of approximately 30 that covers the Wawa supracrustal rocks prevents serious tectonic modeling of the belt. Opinions expressed herein will be subject to modification in subsequent reports.

Prior to initiation of mapping the structural complexity of the belt was recognized and emphasis was therefore placed on deciphering the major regional structures and not on smaller more local detailed investigations.

Mapping has proceeded to the area of Goudreau and the preliminary assessment of the data suggests that the possibility exists that the Wawa supracrustal rocks young northward and represent a monoclinial sequence. What may have formerly been a relatively simple stratigraphic package, has been folded, sometimes into a recumbent position and cross faulted. Folding and cross faulting introduces correlation problems and make defining the original form of the Wawa supracrustal rocks very difficult. Goodwin (1962, p.527) considered the faulting and folding in the Wawa supracrustal rocks as not following a simple stress pattern, however the author considers the dominant stress pattern to be southeast to northwest compression followed by stress relief.

The lateral continuity of the stratigraphic package including the Michipicoten Iron Formation and regional zones of hydrothermal alteration are exemplified in the north-facing monoclinial sequence stretching from the Helen Iron Range to the Josephine-Bartlett Iron Range, a distance of 17.6 km. This linear stratigraphic package implies a linear fault-or rift-controlled development of the supracrustal section. Whatever the shape of the original supracrustal sequence, the sequence was subjected to thrusting or compression from the southeast, possibly due to clockwise movement on the Kapuskasing Structural Zone. During this period of movement, strike-slip faulting with south side east, reverse faulting such as displayed by the Jubilee Shear Zone and recumbent folding such as observed on the south limb of the Centre Anticline all took place. Reverse faulting and regional strike-slip faulting were probably closely followed by the folding in response to the same stress system. The minor anticline northwest of the Helen Iron Range at Legarde Lake is likely related to movement on the strike-slip Talbot Lake Fault and the minor anticline north of the Magpie River is likely a drag fold related to movement on the strike-slip Magpie River Fault.

This period of deformation was followed by left-lateral transverse faulting. While distinctly a younger event, the event is likely of late Archean age and related to a reactivation of the northwest compressional system that originally deformed the belt. These transverse faults, representing northeast extension cut the supracrustal rocks and are distinctly post-folding as indicated by their relatively straight trends. The early period of deformation appears to be more ductile and the later period of transverse faulting is of a more brittle nature. South of Wawa Lake, the northwest-trending faults are sometimes filled with irregular masses of old mafic intrusive rock with sinuous contacts. These northwest-trending mafic intrusions were not identified north of Wawa Lake. The northwest-trending faults both south and north of Wawa lake are filled by younger, fresh diabase with sharp straight contacts. These dikes are thought to be of Proterozoic age and represent reactivation of the northwest left-lateral faults in Proterozoic time. In several areas, but mainly in the Josephine area, the diabase dikes have been offset by reactivation of strike-slip faulting. This reactivated strike-slip faulting is of unknown age, but certainly post-diabase.

The northwest trending left-lateral strike slip faults show decreasing degrees of offset as they trend northward and with the exception of the Parkhill-Black Trout Lake faults and McVeigh Creek Fault most do not cut the Wawa-Hawk Lake Fault system. The Wawa-Hawk Lake Fault system may exert some control on the development of the northwest-trending transverse faults. Some of the transverse faults can not be traced across Wawa-Hawk Lake system of faults. For at least some of the transverse faults, the Wawa-Hawk Lake system of faults may have served as a buttress that was not crossed during transverse fault development. The presence of a carbonatite at the junction of the Wawa Lake and Hawk Lake faults with the transverse Firesand River Fault indicates mantle involvement along the Wawa-Hawk Lake faults.

Percival (1983, p.667) proposed that as one continues to the east through the Wawa supracrustal rocks one is observing even deeper structural levels of exposure as one approaches the high-grade gneiss terrain of the Kapuskasing Structural Zone. The author concurs with the interpretation of Percival. The author believes that the east side of the northwest-trending transverse faults is up relative to the west. The decreasing amount of offset as one moves northward suggests that the faults are hinged and that their southern portion may have been subjected greater tectonic forces than the northern end. Goodwin (1962, p.566) considered the vertical movement on these transverse faults to exceed horizontal movement. He did not cite criteria for determination of the vertical component of movement.

Moore (1931, p.17) related the left-lateral northwest-striking transverse faults to the development of the Lake Superior Basin and considers them to be Keweenawan in age. The

author considers them to be old faults possibly Archean in age reactivated in the Keweenawan.

PETROLOGY

Petrology of the Wawa supracrustal rocks has not been discussed at length in the literature. Goodwin (1966) investigated the general petrology of the Wawa supracrustal rocks. Goodwin (1966, p. 67) that the extrusive rocks contain less alkalies and calcium but more iron and magnesium than the intrusive rocks. He suggested these chemical differences are due to wide-spread iron-magnesium metasomatism and the leaching of calcium, silica and alkalis from the extrusive rocks. He found that the carbon dioxide content is much higher in the metavolcanic rocks than the intrusive rocks.

The chemical differences can be explained by the greater hydrothermal alteration and metasomatism of the extrusive rocks than the intrusions. The extrusive rocks are more porous and permeable than the massive intrusions. This porosity and permeability permits access by active hydrothermal systems leading to alteration of the metavolcanic rocks.

As a result of intense and pervasive metasomatism of the Wawa supracrustal rocks, sampling of the volcanic rocks needs to be done with extreme caution. The sampling of intermediate to mafic metavolcanic rocks was restricted to massive units and cores of pillows; of the intermediate to felsic metavolcanic rocks, to cores of clasts within breccia units, quartz feldspar crystal tuffs, spherulitic flows, and porphyritic flows. The author considers the quartz porphyry flows, flow banded clasts, and spherulitic flows to most likely approximate the composition of their parent magmas. The quartz-feldspar tuffs display an approximate four fold increase in quartz over that observed in porphyry flows. The finer ash fraction has been winnowed from the tuff and the present rock composition is not equivalent to a magma composition. The compositions of the quartz-feldspar crystal tuffs, however, plot close to those compositions thought to most likely represent magma compositions.

Plotting of cycle one intermediate to felsic and intermediate to mafic volcanic rocks indicates a strongly bimodal group of rocks (Figures 59 and 60).

The mafic metavolcanic rocks indicate the presence of the occasional rare basaltic komatiite in subcycle one. The bulk of the samples analysed are high-magnesium or high-iron tholeiitic basalts. A number of samples also plot as normal basalt. Komatiitic rocks are uncommon in the Wawa supracrustal rocks, being identified only in subcycle one east of Wawa Lake and low in the stratigraphic section.

The bulk of the intermediate to felsic rocks are rhyolites but some dacites are also present. The general absence of intermediate rock compositions indicates a strongly bimodal group of metavolcanic rocks implying that the mafic and felsic parts of the first cycle may have no direct petrogenetic relation. The bimodal nature of Archean volcanism is well established (Goodwin and Smith 1980; Ayres 1983).

Cycle two intermediate to mafic and intermediate to felsic metavolcanic rocks also demonstrate a strongly bimodal character (Figures 61 and 62). The felsic part of cycle two displays a tight clustering which is a result of sampling. Sampling was restricted to clasts in the coarse breccias, nearly all of which contain 1 to 5% phenocrystic quartz and are the closest approximation of original melt composition obtainable. The second cycle intermediate to mafic metavolcanic rocks are highly altered and display somewhat more scatter than first cycle intermediate to mafic metavolcanic rocks. The greater scatter of data is interpreted by the author to be the result of alteration and not due to major differences in original magma compositions. One basaltic komatiite flow was observed in cycle two intermediate to mafic metavolcanic rocks above the Lucy Iron Range. The intermediate to mafic metavolcanic rocks of cycle two display a stronger andesite to basalt grouping and less iron enrichment than cycle one.

The chemical data indicate that on the basis of major element chemistry there is no major difference in composition between the intermediate to felsic rocks of subcycle one, cycle one, and cycle two. The data also indicate that with the possible exception of a lower section in (subcycle 1) cycle one containing basaltic komatiite, cycle one and cycle two appear to be generally similar but with less iron enrichment in cycle two. Diagrams of major element and minor element verses stratigraphic position were prepared for footwall and hanging wall intermediate to mafic metavolcanic rocks. These diagrams (not in report) failed to indicate any major compositional changes between top and bottom of the sections.

STRATIGRAPHY

Coleman and Willmott (1902, p.155) named the intermediate to mafic volcanic rocks exposed at Gros Gap near the metasedimentary rocks the Gros Gap greenstones. The on strike continuation of this series of intermediate to mafic rocks is exposed in the map area in parts of McMurray, Chabanel and Esquega townships and are part of cycle one volcanism. Coleman and Willmott (1902, p.155) referred to the intermediate to felsic volcanic rocks above the Gros Gap greenstones as the Wawa Tuffs. Excellent exposures of these tuffs occur below the Helen, Eleanor, Johnson, Lucy, and Ruth iron ranges. Coleman and Willmott (1902, p.155) named Helen Iron Formation and applied the name Dore for the metasedimentary rocks exposed at Lake Superior and eastward. Coleman and Willmott (1902, p.155, 158) proposed the term Eleanor Slates for the metasedimentary rocks exposed west of Lena Lake. They placed the Eleanor Slates below the Dore metasedimentary rocks, however, mapping in the area indicates that they are part of the Dore metasedimentary rocks exposed on the shore of Lake Superior. Offset to their present position by transverse faulting. Other authors have modified and used the terms, however, the creation of additional formational names since Coleman and Willmott (1902) has not taken place (Collins and Quirke 1926). The term Dore has been retained in the literature up to the present, however, the others were never extensively used and are presently only rarely encountered.

The interpretation of the general stratigraphy for the Wawa supracrustal rocks presented here will likely be modified in subsequent reports. Goodwin (1962, 1966) and Goodwin and Shklanka (1967) investigated the stratigraphy of the Wawa area in detail.

Goodwin and Shklanka (1967, p.790) indicated that the supracrustal stratigraphic section is approximately 3050 m thick in the western part and 9150 m to 12 100 m in the central to eastern part of the supracrustal belt. The thick sections proposed by them are suspect. Faulting and folding makes estimations of stratigraphic sections difficult if not impossible in the western part of the belt. In the eastern area of the belt the thick felsic section has been repeated by folding by the Goudreau Anticline and its true thickness is certainly much less than that reported by Goodwin and Shklanka (1967).

Coarse thick pyroclastic rocks below the Helen Iron Range north of the Magpie River, and at the Magpie Mine in Leclaire Township (outside the map area) are interpreted by Goodwin and Shklanka (1967, p.791) to represent former centres of volcanism. The author concurs with the interpretation that the sites are proximal to a volcanic event but the author has observed no geological evidence relating the three centres to the same cycle of volcanism. On the basis of volcanic stratigraphy and U-Pb isotopic ages by Turek et al.

(1982, 1984), the Magpie Mine and Helen centres are likely the same age and the Magpie River centre much younger.

Goodwin (1962, 1964) and Goodwin and Shklanka (1967) recognized at least two mafic to felsic volcanic cycles. The lower part of the oldest cycle is represented by the Gros Gap greenstone which Goodwin (1966, p.61) estimates varies from 600 m to 6000 m in thickness. This sequence of rocks extends from Lake Superior through Lendrum Township in the west, through to Esquega Township in the east. The mafic flows represent low level mounds and lava plains and vary from 6 to 30 m (average 18 m) in thickness (Goodwin 1966, p.61, 62; Goodwin 1962, p.568).

Extrusion of the felsic metavolcanic rocks followed the mafic volcanism. Goodwin (1962, p.567) proposed that the felsic eruptions were represented by cones, spines, domes and irregular masses of considerable relief. The main unit of intermediate to felsic metavolcanic rocks within the map area lies below the Helen Iron Range and extends eastward to and below the Josephine-Bartlett Iron Range in Corbiere Township. This unit has been referred to as the Wawa Tuffs and is estimated to be 60 to 3050 m thick (Goodwin 1966, p.62).

The first cycle of volcanism is capped by iron formation resulting from hot spring activity and this is in turn capped by renewed mafic volcanism of cycle two (Goodwin 1966, p.60, 63). Goodwin and Shklanka (1967, p.791) considered the iron formation to be a direct product of volcanism and related to hydrothermal activity. They have proposed that the thickest iron formation occurs over the thickest part of the volcanic pile. Tectonic activity has greatly thickened the iron formation at the Helen Iron Range and in areas where the iron formation is much less deformed, the author was observed no obvious close correlation between iron formation thickness and thickness of the underlying intermediate to felsic metavolcanic rocks. Goodwin (1962, p.564) reported that along strike the Michipicoten Iron Formation is enclosed within metasedimentary rocks. Mapping by the author and Massey (1985) failed to confirm this facies change. The Michipicoten Iron Formation has always been observed to occur in a volcanic environment at a position in the stratigraphy separating first and second cycle volcanism. Tanton (1948, p.426) reported that the nature of the metasedimentary rocks adjacent to the basal siderite facies of iron formation is variable and therefore the iron formation does not follow a single stratigraphic horizon implying an unconformable relationship. The author has observed that the footwall tuffs have been reworked and display graded bedding and locally cross bedding. The cross beds may have been interpreted by Tanton (1948) to indicate the rocks are metasedimentary rocks and thus indicate a lack of conformity, however, mapping by the author indicates the iron formation always occurs at the same position in the stratigraphic section and it therefore appears regionally conformable. A high degree of variability does exist in the composition of the

rocks lying below the Michipicoten Iron Formation along strike, however, such variability is to be expected in a volcanic terrain and need not represent a major structural unconformity. Goodwin (1962, p.567, 580) and the author have not observed widespread erosion of rocks underlying the Dore metasedimentary rocks and have observed that volcanism and sedimentation have taken place simultaneously since the metavolcanic and metasedimentary rocks interfinger with each other. Goodwin (1962, p.580) and the author have also observed that conglomerates are lensoid, vary widely in width and occur throughout the sedimentary section rather than just at or near the base. Conglomerates are unsuitable for correlation purposes unless they are well exposed and can be traversed. Goodwin (1962, p.567) suggested some thick conglomerates may be laterally equivalent to thin shale units and the author concurs with this interpretation.

Goodwin (1962, p.580) reported that 'Middle Cycle' metavolcanic rocks (cycle two volcanism) grade upward into the Dore metasedimentary rocks and that both sharp and gradational contacts are present. The contact between the intermediate to mafic metavolcanic rocks and metasedimentary rocks above the Lucy Iron Range is sharp. The metasedimentary-metavolcanic contact southeast of Steep Hill Falls is sharp. North from the Magpie River in the eastern portion of Chabanel Township the first sedimentary unit lies in sharp contact with coarse intermediate to felsic metavolcanic breccias. Continuing northward, these same breccias are gradational vertically and laterally into metasedimentary rocks. The author interprets the centre of second cycle volcanism to be the source for the bulk of the detritus for the Dore metasedimentary rocks and the metasedimentary rocks are not gradational upward from middle cycle intermediate to mafic (cycle two) metavolcanic rocks. The Dore metasedimentary rocks are the detritus from rapid erosion of intermediate to felsic metavolcanic tuffaceous rocks of cycle two. Goodwin (1962, p.567) suggested that erosion to produce the detritus was rapid and subaerial. The presently exposed preserved section indicates subaqueous shallow water to subaerial conditions.

Above cycle two metavolcanic rocks Goodwin (1962, p.567) has interpreted the presence of a third cycle of volcanism referred to by him as the 'Upper Cycle'. He reported the presence of minor felsic pyroclastic rocks in this cycle, however, they were not located by the author. Within the map area, rocks of the third cycle are intermediate to mafic pillowed and massive flows located in north-central Chabanel Township and may represent tectonically repeated cycle one or two intermediate to mafic metavolcanic rocks.

Goodwin and Shklanka (1967, p.792) proposed that the Wawa supracrustal rocks resulted from subsidence and deposition in the central and eastern parts of the area on a platform of intermediate to mafic volcanic rocks. They proposed that the intermediate to felsic metavolcanic rocks formed at extrusive centres in the central portion of the belt and

that their extrusion was accompanied by rapid subsidence. Only a preliminary interpretation of the stratigraphy of the Wawa supracrustal rocks is presented here by the author.

The Wawa supracrustal sequence consists of three and possibly four cycles of metavolcanic rocks. Most of the present mapping has concentrated in the first or oldest cycle of volcanism which is a north facing mafic-felsic sequence bounded by the external granitic terrain and overlain by the laterally extensive Michipicoten Iron Formation. Within the lower mafic part of the first cycle, a discontinuous sequence of intermediate to felsic metavolcanic rocks locally capped with minor iron formation defines an internal lower subcycle or remnant of an volcanic cycles.

Overlying the Michipicoten Iron Formation and lying beneath clastic metasedimentary rocks are approximately 1000 m of second cycle intermediate to mafic metavolcanic rocks. The clastic metasedimentary rocks consist of wacke, siltstone, argillite and conglomerate and are likely the detritus from the intermediate to felsic metavolcanic rocks representing the upper part of second cycle volcanism. A volcanic centre associated with second cycle volcanism is represented by the rocks north of the Magpie River, in Chabanel Township. Lateral correlation of the metasedimentary and metavolcanic rocks is difficult due to faulting and folding. Within incompletely mapped townships in the north-central part of the belt, the clastic metasedimentary rocks are overlain by intermediate to mafic metavolcanic rocks which may define a third cycle of volcanism or represent tectonically repeated stratigraphy. The supracrustal sequence at Wawa has been subjected to strike-slip or thrust faulting, minor reverse faulting and intense folding. The folding has become recumbent and in some areas of the belt such as in Chabanel and Musquash Townships the stratigraphy is overturned. Correlation of lithologic units across Wawa Lake is difficult due to strike-slip or thrust faulting and possible folding beneath Wawa Lake.

After strike-slip or thrust faulting and folding, the supracrustal sequence was broken into fault blocks by a series of northwest-trending left-lateral faults. These northwest-trending faults have been intruded by diabase dikes, and minor post-dike deformation is locally recognizable. In Late Proterozoic time, a carbonatite complex was emplaced within the Archean supracrustal rocks east of the town of Wawa. Numerous lamprophyre dikes which cut the Wawa supracrustal rocks, are probably the same age as the carbonatite intrusion and largely restricted to the area south of Wawa Lake.

The structural complexity of the belt and the broad spectrum of rock types present have made it very difficult to unravel its structural and stratigraphic relationships with absolute certainty. Detailed geochronological and structural studies are required for meaningful structural modeling.

CORRELATION TECHNIQUES

Correlation between various fault-bounded lithologic packages is difficult because of extensive strike-slip and left-lateral transverse faulting and folding. The Michipicoten Iron Formation has proven to be the most reliable lithologic marker horizon represents a period of chemical-clastic sedimentation during a hiatus between first and second cycle volcanism. The individual fault segments are named after the segment of iron formation contained within each faulted block, that is, Lucy Iron Range, Eleanor Iron Range and Josephine-Bartlett Iron Range.

No single method of correlation, by itself, has proven satisfactory in further refining the volcanic stratigraphy of the area. Structure and stratigraphy must be used together to unravel the framework of the belt. Within the mafic and felsic metavolcanic sections, marker horizons are absent. Few laterally continuous, texturally distinctive lithologic units are present, which inhibits correlation over short distances.

Lithologic correlation can be best made on the basis of rock composition rather than physical features such as varioles, pumice, clast size or shape, or pillow morphology. Major lithological contacts are placed at rock compositional breaks which are not necessarily time equivalent. Recognition of major compositional breaks in combination with bedding and facing attitudes permit correlation within and between fault blocks.

Within the central mafic part of the oldest cycle, a discontinuous zone of felsic metavolcanic rocks defines an internal subcycle which is locally capped with iron formation. The felsic metavolcanic rocks of the subcycle consist of tuffs, lapilli tuffs, quartz-feldspar crystal tuffs and minor breccia. The iron formation of the subcycle one consists of a lower sulphide and upper chert member and is narrower and more discontinuous than the Michipicoten Iron Formation that caps the major cycle. Carbonate facies (siderite) have not been observed by the author in this iron formation, and the chert-magnetite, and graphite-argillite facies are either absent or only poorly developed. Carbonate facies iron formation has been reported to be present on the Kathleen Iron Range which is part of this internal cycle (AFRO) but this could not confirmed by the present survey.

By contrast, within the Michipicoten Iron Formation a consistent facies relationship has proven to be a reliable facing indicator and this feature assists in correlating between fault blocks. From bottom to top the commonly observed facies sequence the Michipicoten Iron Formation is siderite, pyrite, chert-magnetite-wacke, chert-wacke, and argillite-pyrite-graphite (Figure 63). One or more of these facies may be absent in any given area but where two or more are present, facing direction can be determined.

A polymictic mafic breccia at the top of the intermediate to mafic part of the oldest cycle and a ferruginous dolomite stratigraphically above the breccia have proven to be reliable local marker horizons beneath the Lucy, Ruth, and Josephine-Bartlett iron ranges (Figures 64 and 65).

The mafic breccia on Brooks Lake, Chabanel Township likely consists of more than one flow unit and contains considerable carbonate. The clasts are rounded to angular and more felsic than the dark green to black matrix. They commonly display both a 1 to 2 mm reaction rim and an accretionary rim up to 4 to 6 mm thick. The breccia unit, which displays very crude bedding and poor sorting, is locally polymictic containing iron formation and sulphide clasts in addition to felsic volcanic clasts. At the Lucy Iron Range and within the Josephine area, Corbiere Township some of the volcanic clasts are vesicular and pumiceous.

The ferruginous dolomite associated with the mafic breccia is fine-grained, massive and rusty weathering, with a thinly bedded base. The unit commonly displays a random pattern of criss-crossing stringers of quartz. Rusty orange-brown weathering makes this unit easily recognizable in the field.

The metavolcanic rocks of the oldest cycle consist of a lower sequence of massive to pillowed metavolcanic rocks of high magnesium and iron tholeiite composition (Figures 64 and 65). The overlying felsic metavolcanic rocks consist of tuff, lapilli tuff, feldspar crystal tuff, quartz-feldspar crystal tuff, spherulitic flows, and coarse breccias of rhyolite to dacite composition. The calc-alkalic and tholeiitic parts of the oldest cycle are compositionally strongly bimodal, implying no simple direct petrogenetic relationship. Mapping has disclosed numerous magnetite-bearing flows in the mafic part of the early cycle and these could be locally used as geophysical marker horizons.

The first and second cycle intermediate to mafic and intermediate to felsic metavolcanic rocks display similar primary structures and are indistinguishable in the field.

The Hawk Lake Granitic Complex which contains inclusions of the mafic part of the oldest cycle has been dated by U-Pb zircon techniques as 2888 ± 2 Ma. (Turek 1983; Turek et al. 1984) and felsic tuffs immediately below the Michipicoten Iron Formation at the Helen Iron Range have been dated by U-Pb techniques as 2749 ± 2 Ma. (Turek et al. 1982). On the basis of these isotopic ages, the oldest cycle is 130 million years in duration. The felsic metavolcanic rocks of the second cycle have been dated by U-Pb techniques as 2696 ± 2 Ma. (Turek et al. 1982). Therefore, the time required to develop the Michipicoten Iron Formation, deposit approximately 1000 m of intermediate to mafic volcanic rocks, and extrude a large part of the intermediate to felsic volcanic rocks of cycle two is approximately 50 my.

Regional geophysical surveys could be great assistance in establishing possible regional correlation. Regional geophysical surveys had not been completed when this field work was being done

ECONOMIC GEOLOGY

BASE METALS

The Wawa area has not been known as a base metal mining camp even though the geology appears favourable to the presence of base metal deposits. Within the project area, two base metal deposits have been extensively tested. The Firespur Explorations Limited (former Lakemount Mines Limited) property in Esquega Township contains in excess of one million tons of disseminated copper-nickel sulphide mineralization with platinum group element values.

In Lastheels Township, molybdenite occurs in quartz veins in a migmatite area marginal to the Wawa supracrustal rocks. This molybdenite mineralization underwent extensive testing but no tonnage or grade has been clearly outlined.

At the Firespur Explorations Limited property, one showing of massive chalcopyrite, sphalerite and pyrite occurs along the contact with a quartz porphyry intrusion and schistose mafic metavolcanic rocks. Several showings of sphalerite and galena in quartz veins and one showing of chalcopyrite and pyrite in a shear zone also occur on the Firespur Explorations Limited property.

Chalcopyrite, pyrite, sphalerite and galena occurs in numerous auriferous quartz veins in the area. While this base metal mineralization has no economic value due to its small volume, its presence in a quartz vein is considered to be a favourable indicator for the occurrence of gold values.

IRON DEPOSITS

The iron deposits of the Michipicoten area have made the greatest long term economic contribution to the area. Production has been largely of siderite-pyrite ore but some production of hematite-goethite took place at the Helen Iron Range at the turn of the century.

All production has been from one iron formation unit that has been broken up by left-lateral faulting into various fault blocks referred to as ranges. The iron formation displays a consistent order of lithologic distribution from siderite to pyrite to banded chert to argillite-pyrite-graphite from the stratigraphic bottom to top. The facies vary greatly from place to place in their respective degree of development and preservation. The term iron formation collectively refers to all these various lithologies and the author refers to the iron carbonate-iron sulphide-banded chert + graphite as Michipicoten-type Iron Formation. The development of carbonate-sulphide facies of iron formation reaches major proportions in the

Michipicoten area and it should be considered the type area for iron formations displaying these facies.

The Michipicoten Iron Formation occurs at the top of the first cycle of mafic to felsic volcanism forming a distinct marker horizon which may or may not be time equivalent. The iron formation is overlain by intermediate to mafic massive and pillowed flows of second cycle volcanism.

Early investigators of the Michipicoten Iron Formation interpreted the carbonate and sulphide facies to be hydrothermal replacements of sheared tuffs ponded below an impervious banded silica cap (Collins and Quirke 1927; Bruce 1931; Moore 1931; Moore and Armstrong 1946; Richter 1952). More recent proposals would interpret the iron formation to be a volcanic-fumarolic product formed during volcanism in the presence of biological activity (Goodwin 1962, 1966; Goodwin et al. 1976; Young 1951, 1953). The author concurs with the most recent proposals.

Most, but not all past and present producing iron mines of the Wawa area, occur within Chabanel Township which lies within the limits of this project. Table 11 itemizes iron ore production and reserves from these deposits.

Collins and Quirke (1926, p.62-63) reported that traces of gold are common in the pyrite members of the Michipicoten Iron Formation. The lower portions of the Lucy Iron Range contain an estimated 1% euhedral prismatic to needle-like arsenopyrite crystals in fine grained massive siderite. Since gold is commonly associated with arsenopyrite, a sample of corner of Cowie Township (outside the present map area) and they reported assays of 0.02 to 1.10% Ni from sulphide facies iron formation of the "C" Iron Range of the Goudreau area.

Galena occurs filling fractures in pyrite-bearing siderite on the M3 level of the MacLeod Mine within the Helen Iron Range. A specimen of this material returned 31.2% Pb and 144 ppm Ag (Geoscience Laboratories, Ontario Geological Survey).

Richter (1952, p.75) reported the presence of chalcopyrite, sphalerite, galena and gold in late hydrothermal veins cutting the Ruth, Cline, Rand No.2, East Brooks and Helen iron ranges. Quartz veins cut the siderite of the Lucy Iron Range however base metal mineralization has not been observed within these veins and a similar veining at the other iron ranges has not been observed by the author. Richter (1952, p.75) reported the presence of sphalerite in association with pyrrhotite within the Big Lake, Lucy and East Brooks iron ranges.

It has been suggested that the Michipicoten Iron Formation may contain anomalous concentrations of gold, nickel, copper, zinc, manganese and arsenic (Collins and Quirke 1926, p.73), however, extensive review of exploration data within this project area and throughout

the Wawa-Goudreau area indicates that testing of the Michipicoten-type Iron Formation has been haphazard and base metal contents are generally low. Random samples collected by the field party failed to indicate the presence anomalous gold or base metals.

GOLD

The gold deposits of the Michipicoten area located southeast of the town of Wawa have been the subject of a number of reports. The gold properties of the Michipicoten area at the time of mapping had long been abandoned and both underground and surface exposures that were available to earlier investigators were not available to the author. However, since the time of mapping there has been a considerable amount of exploration and development completed in the area. The most recent development of a gold property has been the joint Citadel Gold Mines Incorporated - Pango Gold Mines Limited effort along the Jubilee Shear Zone which was last operated in 1969. This work was completed years before the present work was undertaken. As a result of the present status of the gold properties the descriptive data concerning mineralization and individual properties is dominantly a condensation of the early reports. The most complete description of the mineralization south and east of Wawa is that of Frohberg (1933, 1935) and property descriptions are by Frohberg (1935), Moore (1931), Gledhill (1927) and Rupert (1979). The present survey emphasized the regional geology and structure of the deposits.

The gold deposits of the Michipicoten gold belt occur in shear zones or quartz veins cutting the diorite to granodiorite Jubilee Stock or in quartz veins cutting intermediate to felsic tuffs surrounding and dipping radially away from the stock. Some gold showings such as the Golden Reed occur marginal to small satellite intrusions that are likely related to the Jubilee Stock.

The gold deposits occur in shear zones, for example, the Citadel Gold Mines Incorporated-Pango Gold Mines Limited property or the former Jubilee gold mine; or in quartz veins, for example the former Parkhill or Darwin Mines.

Frohberg (1935, p.51) described the quartz veins as occurring in two sets: one set strikes 320 to 340°, dips northeast and a second set strikes 050 to 090° and dips south. The first set is represented by the Minto, Grace (Darwin), Deep Lake and Parkhill No.4 veins and the second set by the Parkhill Vein. Barren quartz veins have the same strike as the gold-bearing veins but appear to be younger. The veins are represented by a succession of lenticular quartz bodies that vary from a few yards to more than 33 m in length and from a fraction of a centimeter to more than 1.5 m in width (Frohberg 1935, p.51). The downward extension of the quartz veins exceeds their horizontal length with a length to width ratio of

approximately 1:5 and they pitch at approximately 60° to the right looking down the dip of the vein structure (Frohberg 1935, p.51).

In shear zones, the gold-bearing quartz occurs as short stringers or large lenses which may follow one another at short intervals, or overlap (Frohberg 1935, p.52-53). Frohberg (1935, p.52) found some shear zones to be persistent along strike for distances up to 0.8 km while others disappeared in a short distance. The shear zones are found in all rock types and vary from a few centimeters to 3.3 m in width, however, the Jubilee Shear Zone is approximately 16.5 m in width (Frohberg 1935, p.52).

Within the shear zones, the quartz stringers commonly occur in the wall rocks beyond the margins of the quartz lenses and therefore, the presence of quartz stringers may indicate the nearby presence of a quartz body (Frohberg 1935 p.52, 53). Frohberg (1935, p.53) reported no difference between ore bodies consisting of quartz stringers and those consisting of quartz bodies or lenses.

Frohberg (1935 p.53) observed that some veins have sharp walls and that most are irregular in outline. All the veins contain wall rock inclusions, most of which are rounded rather than angular. The gradual fading of some wall rock fragments into vein material has prompted Frohberg (1935 p.54) to postulate vein formation by replacement. He found few cavities in the veins.

Quartz is the most common vein mineral and in those rare veins where carbonate is dominant over quartz, the gold content is poor (Frohberg 1935 p.54). Barren quartz veins are commonly coarsely crystalline, milky and referred to as "bull" quartz. The gold-bearing quartz is greasy lustered, grey white to grey blue in colour and displays a sugary texture. The gold bearing vein quartz displays a wavy extinction and mortar texture in thin section (Frohberg 1935 p.55).

There are two generations of quartz with the younger quartz occurring as coarse crystalline glassy milky quartz that cuts the older granular variety (Frohberg 1935 p.55; Gledhill 1927 p.25). Gold mineralization is restricted to the older, deformed quartz veins.

Carbonate is present in most quartz veins as calcite or ankerite and it may also occur as distinct veins parallel to the gold-bearing quartz veins (Frohberg 1935 p.55). Within the gold veins, the carbonate is generally fine-grained and in the barren veins it is generally coarse-grained. Frohberg (1935 p.56) defined three generations of carbonate in the Grace Vein:

1. Early carbonate deposited along with sulphides.
2. Barren carbonate possibly deposited contemporaneously with carbonate veining of the wall rocks.

3. Late carbonate associated with gold mineralization and chalcopyrite.

Tourmaline is a common gauge mineral in the Michipicoten gold deposits occurring both in the quartz veins and wall rocks as black needle-like crystals (Frohberg 1935 p.57, 64). Frohberg (1935, p.57, 64) observed that the tourmaline is an early formed mineral and cracks in the crystals are commonly filled with sulphide. Means (1914) has described tourmaline in quartz veins from Mackey Point where it occurs with quartz, carbonates and minor sulphides.

Frohberg (1935 p.58-59) found that arsenopyrite is paragenetically the oldest sulphide and that it occurs as poorly crystalline masses in the veins and as euhedral prisms and needles in the wall rocks. He reported that 80% of the sulphide in the Grace Vein is arsenopyrite and that gold occurs in the arsenopyrite as submicroscopic grains.

Pyrrhotite is common in most gold quartz veins and is subordinate to arsenopyrite as a gold carrier (Frohberg 1935 p.60). Pyrrhotite is commonly altered to pyrite.

Pyrite is the dominant sulphide in some veins and two generations are recognizable (Frohberg 1935 p.61). Frohberg (1935 p.61) reported the older pyrite to be crystalline and in places fractured and cemented with carbonate. The younger pyrite is associated with carbonate and chalcopyrite and not all of the pyrite is the result of pyrrhotite breakdown. Gledhill (1927 p.22) reported that pyrite and chalcopyrite in the gold veins contain approximately 16 times the gold content as the associated pyrrhotite.

Chalcopyrite occurs in many veins but only in minor amounts (Frohberg 1935 p.62). Frohberg (1935 p.63) recognized three generations of chalcopyrite, some of which replaces earlier-formed sulphides and determined that gold deposition occurs with the latest generation of chalcopyrite.

Galena, sphalerite, marcasite, cubanite and bluish green amphibole occur in the quartz veins but are of only minor interest.

All gold occurs as native metal and no tellurides have been identified in the Michipicoten deposits (Frohberg 1935 p.57). Frohberg (1935 p.57-58) described the gold as occurring as flakes, leafs, grains and irregular aggregates dominantly occurring in vein quartz but also present in altered wall rock close to veins where it occurs as flakes and leafs along minute fractures. Gold occurs along subcapillary fractures in quartz and it may be associated with late formed carbonates (Frohberg 1935 p.58). Frohberg (1935 p.58) observed that gold may coat the early formed minerals and that it is deposited along cracks within and forms crusts upon, early formed sulphides. He observed that gold replaces most sulphide only to a minor extent, the notable exception being pyrrhotite which undergoes extensive replacement. Gold is the latest mineral to be deposited and is found intergrown with all early formed minerals (Frohberg 1935 p.58). Gold displays a preference for sulphides; pyrite in most

veins, arsenopyrite in the Grace Vein (Frohberg 1935 p.58). Contemporaneous with the gold and quartz vein deposition is wall rock alteration described as not being uniform and consisting of biotite, chlorite and sericite each of which may dominate in a given vein Frohberg (1935 p.64). He considered the chlorite-biotite growth to be influenced by numerous parallel shear planes. Tourmaline is present as small black needles in the wall rock of most deposits but is conspicuous in only a few veins such as the Hornblende or MacKey Point (Frohberg 1935 p.64). Wall rock alteration is accompanied by sulphide impregnation which may carry gold for distances up to 7.5 cm from the gold veins (Frohberg 1935, 64). The width of the alteration approximates that of the shear zone which hosts the veins.

Frohberg (1935 p.64-65) listed the early alteration minerals as albite, biotite and tourmaline and that locally biotite replaces the other two. Arsenopyrite is the only sulphide deposited at that earlier time. Frohberg (1935, p.65) indicated a second stage of alteration consisting of chloritization of early biotite with accompanying pyrite and pyrrhotite and minor carbonate deposition. Some pyrite and pyrrhotite fills fractures in tourmaline and is intergrown with early formed arsenopyrite during the second stage (Frohberg 1935, p.65, 67). Frohberg's (1935 p.65-66) final stage of alteration is one of sericitization and carbonatization which replaces the earlier alteration minerals: albite and chlorite. Frohberg (1935 p.66) observed that tourmaline may be replaced by sericite in some cases. There may be two generations of tourmaline. He also observed that sericite is replaced and tourmaline attacked during late carbonatization and that all sulphides except late generation chalcopyrite, pyrite and native gold give evidence of replacement. The carbonatization process is considered by Frohberg (1935 p.67) to be related to late barren carbonate veins and stringers found in the vein quartz and wall rock. It is older than the feldspar-carbonate veins that cut the mineralized veins. The sequence of wall rock alteration displays a change from high temperature tourmalinization, albitization and biotitization to low temperature sericitization and carbonatization. Frohberg (1935 p.67) interprets the process as being one of introducing alkalies and boron. Gledhill (1927 p.24) analyzed fresh granodiorite of the Jubilee Stock and altered granodiorite next to a mineralized vein and found a loss of Na_2O and CaO and a gain in SiO_2 , TiO_2 , Al_2O_3 , Fe_2O_3 , FeO , MgO , K_2O and H_2O in the altered granodiorite.

Red to brick red quartz-feldspar veins consisting of carbonate, orthoclase, albite and minor rutile, octahedrite, fluorite and apatite strike northeast, dip northwest and intersect the gold quartz veins at right or acute angles (Frohberg 1935, p.68, 69). Frohberg (1935, p.68) reported that the veins cut young diabase dikes but not the lamprophyres which occur in zones containing the quartz-carbonate veins. He described the quartz-feldspar veins as being narrow and that they fade rapidly into unaltered country rock. The alteration associated with

the quartz-feldspar veins is best developed where the veins cut metavolcanic rocks and no alteration is displayed where they occupy fractures in quartz. The veins display slight alteration of wall rock where they cut the plutonic rocks of the Jubilee Granitic Stock. Potassium feldspar replacement is extensive where sericite is present and is contemporaneous with the formation of iron oxide particles that cloud the feldspars (Frohberg 1935, p.69). Frohberg (1935, p.69) reported that feldspar development can be traced into the wall rocks up to 50 cm and that carbonate may extensively replace the feldspar leaving only small remnants of feldspar and small iron oxide particles as inclusions scattered throughout the carbonate. He found the carbonate to be dominantly calcite with minor amounts of magnesium and iron carbonate and that minor quantities of fluorite, rutile, octahedrite and chlorine-bearing apatite are present. Frohberg (1935, p.70) observed that some of the red quartz-feldspar veins had been reopened and the fragments cemented with later dolomite, quartz, calcite, pyrite and stibnite. He reported that interfragment cavities are lined with quartz or dolomite and that these are then coated with calcite, pyrite, or stibnite. The carbonate-feldspar veins form in two stages; the first is feldspar, apatite, fluorite, octahedrite, rutile and the second is carbonate. Frohberg (1935 p.71) classified the quartz-feldspar veins as hydrothermal or pneumatolytic.

Frohberg (1935, p.73) observed that no strong rules exist for ore localization. Some ore bodies at the Parkhill and Darwin Mines are found near vein junctions but vein intersections are generally unfavourable for ore. Some ore is found where inconspicuous shear zones join the vein structure and other ore occurs along flat-pitching pre-mineralizing folds. Mechanical deformation of veins must precede mineralization since undeformed veins are barren (Frohberg 1935 p.73). Frohberg (1935 p.73) suggested that the wall rock chemistry may have had an influence on ore deposition and he reported that no relationship exists between gold and the lamprophyre dikes. The gold-quartz veins were observed to fade into the wall rock and are considered to be of replacement origin by Frohberg (1935 p.74). Gledhill (1927 p.28) interpreted the veins to be epigenetic replacement deposits formed in shear zones. Rupert (1979 p.70) reported the presence of gold in lean siliceous iron formation east, southwest and south of the Jubilee Stock, however, the author has failed to locate iron formation inside the ring of quartz feldspar porphyry intrusive rocks partially enclosing the stock and assays of iron formation samples exterior to the quartz porphyry failed to show the presence of significant gold.

Gold mineralization in Esquega and Chabanel Townships is related to quartz veins and shearing in association with pyritization, carbonatization and silicification.

North of this map area, in Abotossaway Township, is the Gutscher Lake Stock. Mapping by Studemeister (1985a, p.43) suggested that gold bearing quartz veins at the

periphery of the stock have been emplaced in the thermal aureole of the stock and are related to intrusion, seawater conversions and fracturing associated with emplacement. The presence of most gold bearing quartz veins within the border of the Jubilee Stock or metavolcanic rocks lying within its thermal aureole suggests that a similar model may be applicable to the Jubilee Stock. The stocks may not be the source of the gold but supply heat to drive the convective hydrothermal system needed to concentrate and transport the gold.

RARE EARTH ELEMENTS

The Firesand River carbonatite straddles the boundary of McMurray and Lastheels Townships. This intrusion hosts wide spread low grade niobium mineralization and has been subjected to extensive investigations by Algoma Ore Properties Limited. The carbonatite contains minor apatite mineralization and the core of the intrusion contain rocks known to be favourable to concentrations of the rare earth elements. The geology and exploration history of this complex has recently been described by Sage (1983a).

ANALOGY BETWEEN MASSIVE BASE METAL SULPHIDE DEPOSITS AND MICHIPICOTEN IRON FORMATION

Mapping of the Wawa supracrustal rocks leaves one with the impression that the geology is a very close analogy with most massive base metal sulphide mining camps in the Archean part of the Canadian Shield. The large volume of coarse intermediate to felsic volcanic rock and the extensive and pervasive alteration are highly favourable indicators for the presence of massive base metal sulphides. Indeed, large deposits of iron sulphide are present as a facies of the Michipicoten Iron Formation and the volume of sulphide material is of such a magnitude as to have been mined in the Goudreau area for its sulphur content. Numerous diamond drill programs on sulphide facies iron formation have been completed in the Wawa area. Past and present exploration has not provided encouragement for the presence of base metals or significant precious metal content in the sulphide facies of the iron formation. Major and trace element chemistry completed so far in the Wawa project do not display any strongly anomalous metal concentrations comparable with known base metal massive sulphide camps. The relatively shallow water depth at the time of iron formation deposition, as proposed by the author, Morton and Nebel (1983) and Nebel (1982) is not an environment known to be hostile to formation of massive base metal sulphide deposits (Deptuck et al. 1982). With so many positive features for the Wawa supracrustal rocks the

question arises as to why are there no major base metal deposits? One emphasis of this project has been directed towards examining this question.

Goodwin (1966) was the first to examine the Wawa supracrustal rocks and relate them to base metal and gold mineralization. He recognized that base metal and gold deposits commonly occur in the margins of the felsic porphyry stocks and nearby felsic extrusive rocks. He considers the intrusive, extrusive rocks and their associated mineralization to be related and have a common magmatic parent (Goodwin 1966, p.73).

LeSeelleur (1980) completed the first recent detailed alteration study at the Lucy Iron Range. On the basis of oxygen isotope data, the footwall rocks to the iron formation were subjected to a temperature of 150 to 200°C and that the chert in the upper part of the iron formation indicated a temperature of 70°C (LeSeelleur, 1980, p.47, 53). The footwall volcanic rocks are enriched in Fe, Mn, Ca and Mg but depleted in Si, Al, Na, K and Ti suggesting that the metasomatizing fluids had a mafic source since the chalcophile and siderophile elements are enriched and lithophile elements are depleted (LeSeelleur 1980, p.56). On the basis of rare metal (W and Ag) dilution, reduced iron and estimated solubilities of elements in modern hot springs, LeSeelleur (1980, p.57) suggested that the metasomatized rocks were subjected to high fluid to rock ratios. The broad expanse of the alteration, however, suggests diffuse flow and low fluid/rock ratios. The dominant fluid in ore formation was Archean seawater plus a possible metamorphic outgassing fluid containing CO₂ discharged at the water-volcanic interface (LeSeelleur 1980, p.54, 64, 72). The pervasive, low temperature footwall alteration suggests a defused system, giving low fluid convection (LeSeelleur 1980, p.70). On reacting with the volcanic rocks the hydrothermal fluid produced chlorite, albite, anhydrite, Mg-rich smectites and sulphide (LeSeelleur 1980, p.62) by a process of hydration, oxidation and addition of Mg, Mn, CO₃ and SO₄. La Tour et al. (1980, p.165) have obtained oxygen isotope data on chloritoid-bearing mafic metavolcanic rocks above the Helen Iron Range indicating that the alteration of the metavolcanic rocks occurred at temperatures of 200°C or less. The fluid causing this alteration was interpreted to be Archean seawater.

Extending the work of LeSeelleur (1980), MacMillan (1981, p.1) considered the lack of extensive convection or high fluid residency times to promote rock-fluid equilibrium does not encourage Pb-Cu-Zn supersaturation. LeSeelleur (1980, p.73) considered the Michipicoten Iron Formation to be comparable to a distal massive sulphide deposit using the model of Large (1977) while MacMillan (1981, p.1) proposed that base metal or iron formation deposition may be controlled by the thickness of the cooling volcanic rock pile and the relationship is one of convection rather than proximal-distal position to the vent source. Morton and Nebel (1984, p.1331) have suggested that the high iron chlorite found at the Helen Iron Range is typical of low temperature alteration.

Lockwood (1983, p.1) examined chloritoid alteration in the footwall of the Josephine Iron Range, Corbiere Township and proposed that the alteration was the result of low water/rock ratios and diffuse flow that was permeability controlled.

Morton and Nebel (1984) proposed that the Helen Iron Range is comparable to a Archean base metal massive sulphide deposit and the deposit is underlain by an alteration pipe. Morton and Nebel (1984, p.1319) attributed the lack of base metals in the iron formation to be the result of low temperature and high water to rock ratios. The CO₂-rich fluids depositing the iron formation at the seafloor are metamorphically derived and the metals are likely scavenged from the reservoir rocks (Morton and Nebel 1984, p.1331). However, they recognized that their relatively large interpreted alteration pipe (1.0 km by 900 m) and the intense carbonate alteration are not typical of most massive sulphide deposits (Morton and Nebel 1984, p.1330). These two features by themselves negate any close comparison with alteration pipes associated with massive sulphide deposits. In addition, chloritoid-bearing zones, equal to and greater in extent to the one formed at the Helen Iron Range, are present in the Wawa area, where they are not associated with iron formation. The author, as has Goodwin (1962, 1964) and Goodwin and Shklanka (1967) recognized that the Michipicoten Iron Formation once was a continuous stratigraphic horizon. In all probability, this same iron range can be correlated with similar iron formation in the Goudreau area. One is therefore looking at a stratigraphic horizon extending over many kilometres whose formation must be related to an aquifer of comparable dimensions. The Helen Iron Range is therefore not underlain by an alteration pipe in the classical sense of a base metal massive sulphide deposit.

A modern analog to sulphide deposition in an Archean supracrustal sequence on the scale of the Michipicoten Iron Formation probably does not exist. Comparison with modern hydrothermal vent systems along mid-ocean ridges may be helpful to understand some aspects of sulphide and base metal deposition, however, the tectonic setting of a Archean supracrustal belt compared to a mid-ocean ridge is uncertain. Comparison with mid-ocean ridge hydrothermal systems will be based on two factors: temperature and alteration.

At mid-ocean ridges, alteration by hydrothermal systems associated with sulphide deposits produce smectites or nontronite (Cole 1983, p.171; Marnane and Claque 1983, p.350; Hekinian et al.1977, p.395) and laboratory experimental tests on seawater basalt interaction have also produced smectite (Seyfried and Bischoff 1981, p.135; Seyfried and Mott 1982, p.985; Hajash and Chandler 1981, p.251). Bischoff and Dixon (1975, p.385) produced a montmorillonite plus anhydrite assemblage by reacting seawater with basalt at 220°C and 500 bars. Anhydrite will dissolve in seawater and be removed (Bischoff 1980, p.1968). Lockwood (1983, p.45, 62) studying the chloritoid-bearing intermediate to mafic rocks at the

Josephine Iron Range suggested a smectite precursor and MacMillan (1981, p.46) examining the chloritoid-bearing intermediate to felsic rocks below the Helen Iron Range proposed that nontronite, a variety of smectite was a precursor. Recent studies suggest that the initial alteration by hydrothermal fluids in the Wawa supracrustal rocks developed an alteration mineral assemblage similar to that observed in modern active mid-ocean hydrothermal systems.

At the Atlantis II deep, Red sea, Cole (1983, p.171, 173) recognized three smectite assemblages, two of which contain nontronite. The first two are sulphide-silicate-amorphous formed at 90 to 140°C and silicate-carbonate-oxide formed at approximately 80°C. A third smectite, montmorillonite-beidellite occurs in the sulphate-sulphide-silicate-oxide facies and formed at 160 to 200°C (Cole 1983, p.173). The two nontronites formed at a temperature between the temperature of the brine at discharge (250°C) and that of the brine pool (50° to 60°C) (Cole 1983, p.171). The nontronite forms as a result of mixing of isotopically light incoming brine and isotopically heavier upper layers of the brine pool. Cole (1983, p.173) interpreted the montmorillonite-beidellite formation temperature to indicate alteration at brine temperature at or before discharge.

On the basis of oxygen isotope data, Murnane and Claque (1983, p.350) have proposed that natronite can precipitate from seawater at approximately 57°C. Their observation was made on the Juan de Fuca Ridge and sulphides were not being deposited at the site. At these low temperatures (200°C or less) significant iron and manganese, elements abundant in Michipicoten Iron Formation, can be leached (Murnane and Claque 1983, p.351). Silica, iron and manganese oxides and nontronite can precipitate from these low temperature fluids. In experimental studies of seawater-basalt-glass interactions, Seyfried and Mottle (1982, p.985) produced a smectite-chlorite, anhydrite and hematite mineral assemblage at 300°C and 500 bars pressure. Therefore, minerals precursor to chloritoid formation may also form at reasonably high temperatures.

Hekinian et al.(1977, p.395) found that in the Galapagoes, iron-and manganese rich-sediments are dispersed from the high temperature vent and proposed that the natronite-rich muds were precipitates from fluids carrying components derived from the alteration of basalt. The nontronites are direct precipitates from hydrothermal solutions rather than the products of diagenetic reactions between solutions and sediments (Hekinian et al. 1977, p.395). Manganese fractionates from iron and copper and zinc from iron, by gradients in temperature and oxygenation and thus iron and manganese are dispersed into a lower temperature environment away from the vent (Hekinian et al.1977, p.419). Manganese is a minor but abundant component of the Michipicoten Iron Formation (Collins and Quirke 1926, p.64, 69; Moore and Armstrong 1946, p.72). Hekinian et al. (1977, p.395) found that

in active hydrothermal systems mounds of nontronite are capped with manganese oxide which overlie carbonate mud. The iron is deposited away from the vents as iron hydroxides and may react diagenetically with siliceous microfossils and detrital clays to form potassium- and iron-rich clays (Hekinian et al. 1977, p.395).

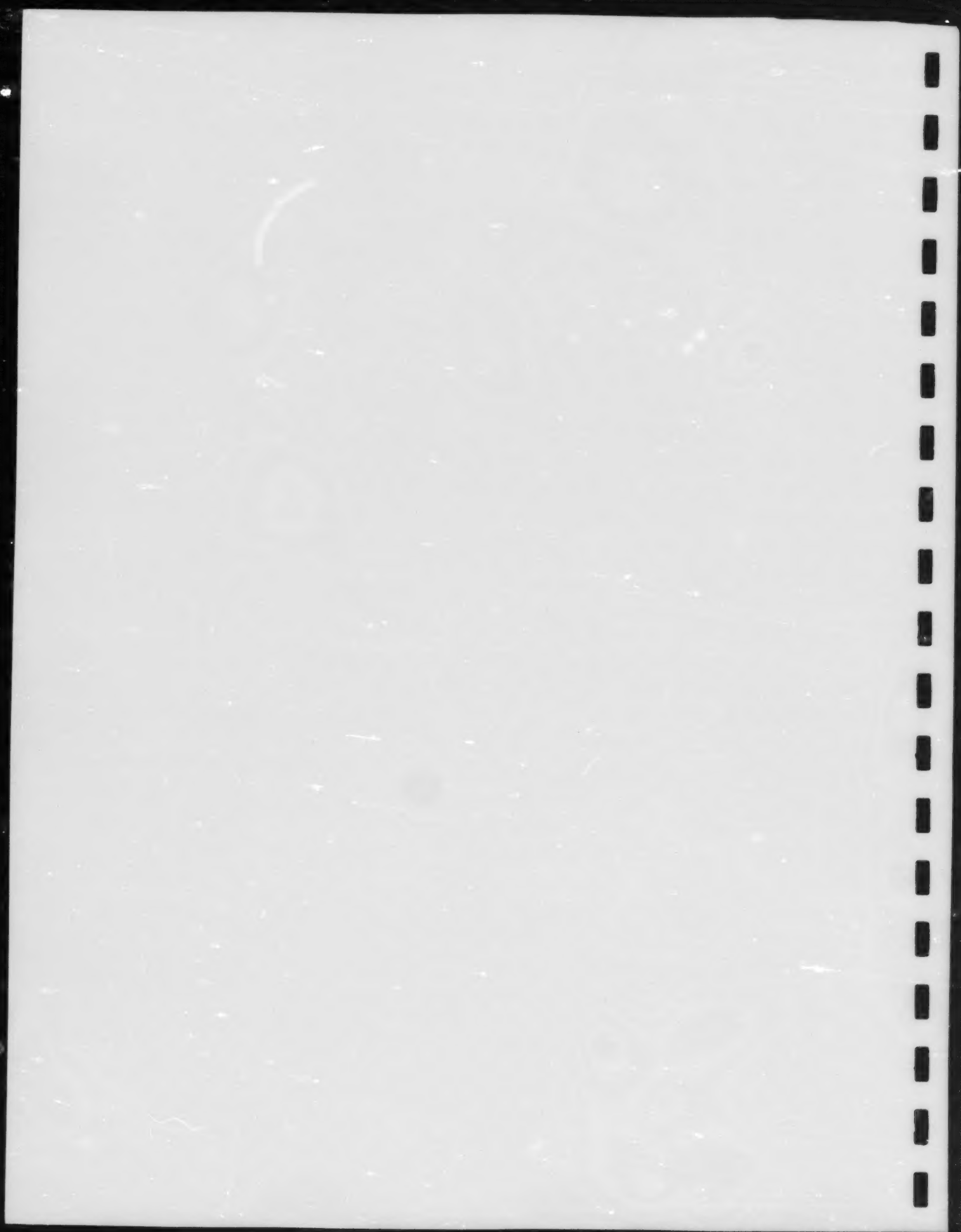
Modern observations on hydrothermal systems indicate the likely possibility that smectite or its variety nontronite was a precursor to the chloritoid-bearing rocks as suggested by Lockwood (1983) and MacMillan (1981).

A second important feature of the chloritoid-bearing rocks or alteration zones is their conformable nature. These zones may be thousands of metres even kilometres in length. Alteration zones associated with base metal sulphide deposits are pipe-like bodies that narrow in depth and are much smaller in diameter than the associated mineralization (Franklin et al. 1981, p.543). These pipe-like alteration zones are associated with fractures and faults (Franklin et al. 1981, p.543). In the modern mid-ocean ridge hydrothermal systems, the sulphides deposit in or on the vent which is controlled by the ridge fracture system (Murnane and Clarque 1983; Haymon 1983). The focused hydrothermal discharge in modern ocean ridge environments can be generally compared with the alteration pipes below massive base metal sulphide deposits. These pipes represent a focused discharge system and infer high water/rock ratios. The conformable regional pattern of chloritoid development in the Wawa area represents a non-focused hydrothermal system. The non-focused nature also implies lack of faulting or fracturing at the time of alteration which would have assisted the development of focused or pipe-like alteration zones. An additional possible implication is that the volcanism at Wawa did not produce major caldera-like structures which would have developed ring fractures, subsidence and resurgence. Such fracturing would have developed the structural features required for focused discharge. Morton and Nebel (1984, p.1331) and Goodwin et al. (1985, p.72) have proposed an alteration pipe below the Helen Iron Range and suggested that the iron formation formed in a caldera environment. The alteration zones below the Helen Iron Range are not pipe-like and mapping has failed to locate faulting that could define the limits of the proposed caldera. If the Helen Iron Range correlates with the iron ranges in Goudreau, which is likely, the proposed caldera would incorporate a large portion of Michipicoten supracrustal belt.

Comparison between the Michipicoten Iron Formation and massive base metal sulphide deposits on the basis of temperature is warranted. LeSeelleur (1980, p.48) on the basis of oxygen isotope data on chert from the siderite within the Michipicoten Iron Formation predicted a deposition temperature of approximately 200°C. The siderite forms the stratigraphic base to the iron formation and should reasonably approximate the maximum deposition temperature. Data about the temperature of deposition of Archean massive

sulphide deposits is scarce. Franklin (et al.1981, p.556) quote a temperature of 240 to 440°C for the Quemont massive sulphide which compares favourably with an approximately 350°C temperature of sulphide deposition observed in the mid-ocean ridge environment (Murnane and Claque 1983, p.350). Sulphide deposition results from mixing with seawater or mixing of higher temperature subsurface waters and ground water (Edmond et al.1979, p.27; Murnane and Claque 1983, p.350). Sulphide precipitation will occur in the vent and cooler iron-manganese rich fluids exit (Edmond et al. 1979, p.27). These end solutions are high in iron and manganese and capable of forming iron-and manganese-rich sediments possibly comparable to some iron formation. In comparing discharge products of hot hydrothermal vents with cooler vents, Haymon (1983, p.493) observed that on the east Pacific rise the hottest vents spew forth sulphide rich fluid, principally pyrrhotite and sphalerite, while cooler vents spew forth silica, barite and pyrite. Unless vent temperature or hydrothermal fluid temperature reaches a relatively high level, sulphide deposition will not occur even in a proximal vent setting. Temperature plays an important role in sulphide transport and below 350°C effective base metal transport is not likely (Bischoff 1980, p.1465). If the system is rock dominated by low water-rock ratios, as characterizes the Michipicoten Iron Formation, fluids are incapable of holding large quantities of base metals (Bischoff 1980, p.1465). In rock dominated systems metal-rich fluids form at 350 to 400°C (Seyfried and Mottle 1982, p.1000) or at twice the depositional temperature indicated for the Michipicoten Iron Formation. Rock dominant systems produce nearly neutral solutions with only 2 to 3 ppm iron and manganese even at a temperature of 350°C (Seyfried and Mottle 1982, p.999). In summation, at high water/rock ratios heavy metal deposits can form at temperatures equal to or greater than 300°C but at low water/rock ratios temperatures equal to or greater than 400°C are required to form heavy metal deposits (Seyfried and Bischoff 1981, p.135). The isotope data on the Michipicoten Iron Formation indicate that the high depositional temperatures required to accumulate base metals were never obtained.

In experiments on seawater reaction with basalt, magnesium and sulfate are depleted (Bischoff and Dickson 1975, p.385; Bischoff 1980, p.1468; Seyfried and Mottle 1982, p.985; Seyfried and Bischoff 1981, p.135). At 200°C and 500 bars pressure, Mg and SO₄ are removed from the fluid and SiO₂ reaches saturation. At the same time, calcium content drops as anhydrite precipitates but increases later by a factor of two and potassium increases to a steady state level (Bischoff and Dickson 1975, p.385). At 200°C or 300°C, this reaction changes the fluid from slightly basic to slightly acid and Mg is removed as Mg (OH)₂ and incorporated into secondary clay (Bischoff and Dickson 1975, p.385; Seyfried and Mottle 1982, p.985). Magnesium removal as Mg (OH)₂ lowers the pH, dramatically increases the solubility of Fe, Mn and Zn and provides a measure of water/rock ratios (Seyfried and



Mottle 1982, p.999, 1001; Hajash and Chandler 1981, p.25). As Mg removal approaches completion, pH rises and the metal concentrations drop, however, under seawater dominated systems (high water-rock ratios) Mg supply exceeds the amount that can be accommodated in the secondary minerals, pH remains low and metal concentration remains high (Seyfried and Mottle 1982, p.993; Hajash and Chandler 1981, p.240, 251). Therefore pH is much more important than chloride-complexing in removing Fe, Mn, Zn, and Cu. Within seawater-dominated systems, significant heavy metal concentrations could be maintained at low temperatures if the pH is low (Seyfried and Mottle 1982, p.999; Seyfried and Bischoff 1981, p.135), however, in a CO₂ rich system such as the Michipicoten Iron Formation a low pH is not likely. The higher pH may also be a significant factor in the lack of base metals within the Michipicoten Iron Formation. Goodwin et al. (1985, p.82) suggested a pH of 5.0 increasing to 6.5 during Michipicoten Iron Formation deposition. In rock dominant systems, Seyfried and Mottle (1982, p.999) found that seawater reaction with basalt produced neutral solutions with only 2 to 3 ppm Fe and Mn even at temperatures of 350°C, nearly twice the deposition temperatures of the Michipicoten Iron Formation. Studies of chloritoid-bearing rocks suggest rock dominated hydrothermal systems and thus a low potential for metal solution and transport. At high water-rock ratios and at 300°C, Seyfried and Mottle (1982, p.985) observed the removal of Na, Ca, Cu, Zn and CO₂ and the removal of most K, Ba, Sr and Mn from the silicate minerals in the basalt, conditions which apparently did not exist at the time of the Michipicoten Iron Formation deposition. They observed that Al, Si, H₂S and Co were mobilized and that V, Cr and Ni were not.

In summary, a number of differences and few similarities exist between massive base metal sulphide deposits and Michipicoten Iron Formation. These are as follows:

1. The precursor to the chloritoid alteration associated with some of Michipicoten Iron Formation may be smectite or nontronite, minerals commonly associated with hydrothermal mid-ocean ridge vent systems. These minerals form in relatively low temperature vent systems and therefore the precursor alteration minerals to the chloritoid alteration at Wawa may be analogous to modern low temperature mid-ocean ridge vent systems.
2. In hydrothermal vent systems Mn and Fe, two components of the Michipicoten Iron Formation, are deposited in a relatively low temperature distal setting from the vent. Base metal sulphides are deposited in a high temperature environment proximal to the vent.
3. Alteration zones associated with massive sulphide deposits are pipe-like bodies that narrow in depth. This pattern contrasts with the broad, regional, stratiform alteration pattern found in the Wawa area.

4. Pipe-like alterations associated with massive base metal deposits are commonly associated with faults. The lack of alteration pipes in the Wawa alteration patterns implies a lack of faulting and of focused discharge of hydrothermal fluids.
5. The lack of evidence for focused discharge, implying the lack of faulting, indirectly implies the lack of caldera collapse and resurgence features that may be considered favourable for base metal deposition.
6. Oxygen isotope data indicate that the Michipicoten Iron Formation was deposited at approximately 200°C. Base metal sulphide deposits forming in modern mid ocean ridge hydrothermal systems are deposited at approximately 350°C or greater. Effective base metal transport does not occur below 350°C and base metals would not be available for deposition during low temperature deposition of the Michipicoten Iron Formation.
8. Rock dominated systems, or low water/rock ratio systems produce nearly neutral fluids which cannot transport significant quantities of base metals. The Michipicoten system is one of low water/rock ratio.
9. Low pH systems increase the solubility of Fe, Mn and Zn; neutral systems or basic systems could not transport significant heavy metals. Low pH systems are characteristic of high water/rock ratio systems which contrasts with the low water/rock ratio system found at Wawa. The Wawa system was depositing both carbonate and sulphide facies iron formation. Therefore, a low pH hydrothermal system, required to dissolve the base metals of economic interest, did not exist.

RECOMMENDATIONS TO THE FUTURE EXPLORATION

The map area is known principally for its iron deposits and the dollar value of iron production far exceeds that of the limited gold production. The iron deposits are well known and have undergone extensive surface diamond drilling since 1900. The discovery of additional iron deposits is not likely, but much additional tonnage likely exists below the limit of present diamond drilling and development. Base metal mineralization is not common in this map area.

IRON DEPOSITS

Siderite is known to exist at the Helen Iron Range to a depth of approximately 1.5 km and likely extends to greater depths. The profitable extraction of these reserves will likely depend in part on the development of the technology to extract large tonnages from these depths quickly and cheaply. The MacLeod Mine is the only remaining operating underground iron mine in North America as well as being the only mine extracting and sintering siderite. Under present day costs and regulations, it would be doubtful that a similar deposit, if located elsewhere in the Canadian Shield, would be considered a viable drilling target let alone a productive deposit. The presently existing viability of the deposit is likely due to a large extent to having the infrastructure such as railroads, mine, town site, and sintering plant already in place and operating. The cost of developing such an infrastructure at current prices would prevent the extraction of a similar deposit elsewhere.

All open pit ore has been removed from the Eleanor Iron Range but underground reserves could be developed. Limited open pit reserves are present at the Lucy and Ruth Iron Ranges but the bulk of the tonnages within these ranges would have to be extracted by underground methods.

On the basis of records in the Assessment File Research Office, Toronto, anomalous levels of Cu and Au occur in a minor iron formation unit overlying intermediate to felsic metavolcanic rocks of subcycle one within the mafic part of the first cycle. Surface samples collected during the present survey did not confirm these reports of anomalous copper and gold nor has assay data submitted to the Assessment Files Research Office subsequently to mapping by the survey.

The value of the main Michipicoten Iron Formation, capping first cycle volcanism is its iron content only. Geochemically anomalous values of copper, nickel, gold and zinc have been reported from this unit (AFRO, Toronto; Collins and Quirke 1926; Richter 1952) but surface sampling during the recent mapping has not indicated significant anomalous base or precious metal contents.

GOLD DEPOSITS

Within the map area, most mineralization occurs in the first cycle of volcanism. Gold mineralization without any other associated economic mineralization occurs in association with the epiclastic tuffs that have been intruded by the Jubilee Stock. These gold deposits are restricted to McMurray Township.

Gold minerization in Esquega Township commonly occurs with minor base metal minerallization. Within Esquega Township, several gold showings occur in subcycle one mafic metavolcanic rocks in association with quartz-feldspar porphyry and mafic intrusions. Minor amounts of pyrite and chalcopyrite are commonly associated with these deposits.

The gold showings in Esquega Township are in most cases quartz veins associated with shearing, silicification and carbonatization at lithologic contacts. These sheared contacts are principally along quartz-feldspar porphyry intrusions. Mafic intrusions of metagabbro are also common in proximity to the showings. Disseminated pyrite and clots of coarse-grained pyrite are common in these quartz veins. These showings generally appear to occur regionally

where metamorphic rank is transitional from greenschist to lower amphibolite or upper greenschist. This transition is recognized in the field by decreasing carbonate content and the appearance of amphibole in the metavolcanic rocks. The amphibole has been altered to chlorite suggesting that it has undergone retrograde metamorphism.

The gold showings occur at approximately the same distance from the contact of the Hawk Lake Granitic Complex and may be related to the thermal aureole of that complex. The possibility exists that one or more rock units once contained gold that has been remobilized and concentrated into veins or shear zones. A distinct lithologic unit which could be a source for the gold has not been recognized.

Within cycle one intermediate to felsic metavolcanic rocks northwest of the MacLeod Mine, several gold showings are present which appear to be areas that are geochemically anomalous in gold but lacking significant ore grade material (ie: Boliden showing, Miller Claim Group, Williamson Claim Group).

South of Wawa in McMurray Township, an area of gold mineralization is associated with the thermal aureole and quartz veining around the Jubilee Stock which appears to be centered within a caldera structure (Sage 1979). The central stock is of dioritic to granodioritic composition, contains numerous blocks of metavolcanic rocks, and locally displays an intrusive breccia margin. The stock is exposed at a structurally high level. An outer ring fracture is occupied by massive quartz-feldspar porphyry that partially encloses the stock. The gold commonly occurs within quartz lenses, cutting and concordant with redeposited tuffaceous units of andesitic to dacitic composition, marginal to the granitic stock. Bedding in the tuffs dips away from the stock and strikes parallel to the metavolcanic-plutonic contact. The coarser rock units are lensoid in plan view, and likely occupy former topographic depressions on the flanks of the former volcano. They represent rapid subaqueous deposition of volcanic detritus from the volcanic edifice which once existed above the Jubilee Stock.

Early studies of the gold deposits south of Wawa classified the deposits as quartz veins (Frohberg 1935; Gledhill 1927). These investigators recognized at least two ages of veining. The gold mineralization was said to be associated with the older quartz veins that display a sugary texture and contain minor concentrations of sulphide, principally pyrite and chalcopyrite. Later, coarsely crystalline quartz veins were described as barren with respect to gold and deficient in sulphides (Gledhill 1927; Frohberg 1935). Samples of coarsely crystalline barren quartz vein material collected during recent mapping generally confirmed these observations.

Recently a re-evaluation of several gold deposits south of Wawa has been completed by Dunraine Mines Limited. At least some of the gold-bearing veins have been referred to as lenses and are interpreted to be sugary quartzites or in some cases recrystallized cherty tuffs deposited within a sequence of redeposited tuffs on the flanks of a former volcano (H. Koza, Dunraine Mines Limited, personal communication, 1983). The lenses are limited in exposure and lack internal bedding and contain volcanoclastic fragments. In this model, gold deposits are considered to have formed either as subaqueous placers or as redeposited gold-bearing cherty tuffs. This interpretation is based on the presence of tuffs displaying good primary sedimentary structures above and below the Parkhill gold-bearing lenses, the crudely conformable nature of some lenses and the presence of gold-bearing siliceous tuff lenses within the epiclastic tuffs. Outlines of underground stopes on existing mine plans could be interpreted to suggest the possibility that meandering streams may have influenced gold distribution. If this model is correct, the source beds proximal to the volcanic vent have likely been removed by erosion of the former volcanic edifice above the Jubilee Stock, and the location of allochthonous deposits of economic significance may be possible. However, the author prefers to interpret the Parkhill veins as quartz veins in shear zones rather than syngenetic deposits.

Gold also occurs as lensoid quartz bodies within altered early shear zones such as the Jubilee Shear Zone, which possibly represent reverse faults, that cut the Jubilee Stock. The

nature of these quartz lenses is uncertain and some could be siliceous mineralized tuffs incorporated into the faults. The reverse faults and strike-slip or thrust faults are the oldest recognized faults in the Wawa area and are offset by northwest-trending left-lateral faults so older structures are more favorable to gold mineralization than younger. In addition to silicification, the shear zones are carbonated and contain minor disseminated pyrite.

More money has probably been spent on looking for and developing gold mines south of Wawa than likely has been taken out in gold (Rupert 1979). Significant gold mineralization south of Wawa in McMurray Township occurs in only two structural settings. These are the Jubilee Shear Zone and the Parkhill-Darwin Vein systems. The author considers the Darwin Shear Zone to be the faulted extension of the Jubilee Shear Zone and the vein system within the Van Sickle and Darwin mines as part of the Parkhill vein system.

Citadel Gold Mines Incorporated have tested the Jubilee Shear Zone to the extent that additional large near surface gold deposits are unlikely. Exploration potential here is likely at depth. Dunraine Mines Limited have drill tested the Darwin Shear Zone at various intervals. This drilling has significantly lowered the potential of this structure but additional testing is warranted between and below existing holes.

The former Parkhill Mine offers potential for additional gold mineralization in addition to possibly examining and removing any ore that remains in the present workings. Short drill holes into the footwall and hanging wall for parallel mineralized veins, and drilling below the bottom level appears warranted. Near surface, gold mineralization between the Parkhill and Van Sickle Mines is not likely present on the basis of Dunraine Mines Limited drilling. If the Parkhill Mine is dewatered, the area between the Parkhill and Van Sickle Mines should be drill tested from the deeper levels.

The ore bodies of the Parkhill Mine plunge west and the area between the Darwin vertical shaft and Parkhill Fault may be worth exploring. The faulted continuation of the plunging Parkhill ore bodies may be too deep for adequate testing but parallel ore bodies may exist and extend upward to higher levels.

The Parkhill Vein has produced most of the gold south of Wawa and is known to have contained very high grade pockets. This vein, where presently exposed at surface, contains little sulphide, is grey white in colour, sugary, and gives off a pungent odor immediately upon fracturing. This odour has been described by various people as rotten onions, garlic, or cyanide. Any vein material with similar properties warrants analysis for gold.

Of the two origins proposed for the Parkhill Vein, that is quartz vein versus quartzite or cherty tuff the author favours quartz vein. This vein has been emplaced concordantly into the enclosing reworked metavolcanic detritus. The vein structure pinches and swells, and has an anastomosing pattern which the author would interpret as more characteristic of a vein rather than a metasedimentary rock. The sugary vein texture is not unique to the Parkhill Vein and sugary quartz veins are common in the Wawa area. No matter which origin one prefers, the vein or quartzite likely extends to greater depths than presently explored and is continuous laterally. The sedimentary model would perhaps favour the presence of a larger volume of gold-bearing material.

In north central Chabanel Township, the Magpie Junction showing is present. This is the only gold occurrence within the map area that exists in cycle two or possibly cycle three metavolcanic rocks. Assay results on file in the Assessment Files Research Office of the Ontario Geological Survey indicate economically significant gold values are present. Work by Cannabec Explorations Limited and surface sampling by others would indicate the occurrence as being only geochemically anomalous in gold.

The Magpie Junction showing is perhaps the best example in the present map area of a gold occurrence which on the basis of assay data of the 1930's is highly promising. However, more recent work has given assay results several orders of magnitude lower than what has been previously reported. Explorers looking for gold in Wawa should use old assay data with extreme caution since recent investigations of several gold showings in the Wawa area have found old data to be very unreliable.

A second word of caution may be warranted. Good values for gold obtained by the field party at the Atnel showing in Esquega Township were confirmed by J. Q. Resources Limited. However, diamond drilling by Dasher Resources Limited indicate the gold is a surficial enrichment feature and high surface values do not extend to depth.

BASE METALS

Base metal showings are nearly all sulphide-bearing quartz veins of limited extent, and are generally restricted to the lower part of the first cycle of volcanism.

A high grade silver, lead, and zinc-bearing quartz vein north of Wawa Lake, in Chabanel Township, is the only mineralization found in the felsic part of the first cycle and in fact, occurs in a quartz diorite intrusion cutting the felsic metavolcanic rocks and not the metavolcanic rocks themselves. This showing lies below the Helen Iron Range and appears to be quite small. Grab samples from this vein exceed 40 ounces per ton in Ag. While impressive assay results are obtainable on grab samples the vein is too small to be the source of large tonnages. This vein appears to be unique since no other vein like it is known in the Wawa area.

The most significant base metal mineralization in the map area is one of disseminated copper and nickel sulphides with platinum values in a mafic intrusion cutting metavolcanic rocks of subcycle one in Esquega Township. This intrusive body sharply crosscuts lithologic trends in subcycle one metavolcanic rocks and warrants additional testing for platinum group elements. The base metal content appears to be too low to be economically viable in the near future.

Immediately south of the disseminated copper and nickel occurrence in Esquega Township, a massive sulphide showing, one meter in width, occurs along a contact between mafic metavolcanic rocks and a quartz porphyry intrusion. Based on diamond drilling by Firespur Explorations Limited this high grade copper, zinc, and silver occurrence does not

appear to be traceable laterally or to depth. Additional lenses of relatively massive base metal sulphide may occur along sheared metavolcanic-quartz porphyry contacts.

Molybdenite-bearing quartz veins occur in the migmitic terrane marginal to the supracrustal rocks in Lastheels Township. This style of mineralization has economic potential if an area can be located where the veins are closely spaced.

The area has been covered by airborne geophysical surveys completed by a number of companies. Geophysically indicated conductive zones are common in Chabanel, Esquega, and parts of McMurray townships. In spite of these efforts, numerous conductors remain to be explained and base metal mineralization may be present. Testing of some of these conductors for base metal sulphides appear warranted.

RARE EARTHS

The Firesand Creek carbonatite intrusion contains widespread low grade subeconomic niobium values (Sage 1983a). The rauhaugite (dolomite) core of the carbonatite is favorable for rare earth element mineralization and should be tested for concentrations of the rare earth elements (Sage 1983a).

REFERENCES

- Abercrombie, S.M. 1981. Stratigraphy of the Lucy Mine Area, Wawa, Ontario; unpublished B.Sc. Thesis, University of Western Ontario, London, Ontario, 81p.
- Aleva, G.J.J. 1959. Geological Report No. 29; prepared for Billiton Maatschappij, N.V., Assessment Files Research Office, Toronto, 4p. with attachments.
- Allen, E.R. 1928. Report on Bond Location, Engineers Holding Company Ltd., Michipicoten Area, Ontario; prepared for Engineers Holding Company Ltd., Assessment Files Research Office, Toronto, 3p.
- American Geological Institute 1972. Glossary of Geology; American Geological Institute, Washington, D.C., 805p.
- Archibald, L.W. 1977. Summary report, Canabec Explorations Ltd. Magpie Junction Property, Chabanel Township, Ontario; prepared for Canabec Explorations Ltd., Assessment Files Research Office, Toronto, 9p.
- Attoh, K. 1981a. Pre- and Post-Dore sequence in the Wawa volcanic belt, Ontario; in current Research, Part B, Geological Survey of Canada Paper 81-113, p.49-54.
- 1981a. Pre- and Post-Dore sequence in the Wawa volcanic belt, Ontario; in Abstract and Proceedings 27th Annual Meeting Institute of Lake Superior Geology.
- Ayres, L.D. 1972. Guide to granitic rock nomenclature used in reports of the Ontario Division of Mines; Ontario Division of Mines, Miscellaneous Paper 52, 14p.
- 1979. Metamorphism in the Superior Province of Northwestern Ontario and its Relationship to Crustal Development; p.25-36 in Metamorphism in the Canadian Shield, Geological Survey of Canada, Paper 78-10, ___p.
- 1983. Bimodal Volcanism in Archean Greenstone Belts Exemplified by Greywacke Composition, Lake Superior Park, Ontario; Canadian Journal Earth Sciences, v.20, p.1168-1194.
- Baird, D.S. 1943(?). Geological report on the Corinth Holdings of Lakemount Prospecting Syndicate; prepared for Lakemount Prospecting Syndicate, Assessment Files Research Office, Toronto, 17p.
- Bell, J.M. 1905. Iron Ranges of Michipicoten West; Ontario Bureau of Mines, v.XIV, pt.1 p.278-355.
- Bell, R. 1898. Geology of the Michipicoten District; Geological Survey Canada, Summary Report v.11, p.99A-106A.
- Belyea, R.E. 19(?). To the Shareholders of Lakemount Mines; report to shareholders of Lakemount Mines Ltd., Assessment Files Research Office, Toronto, 3p.

- Beswick, A.E. and Soucie, G. 1978. A Correction Procedure for Metasomatism in an Archean Greenstone Belt; *Precambrian Research*, v.6, p.235-248.
- Bischoff, J.L. 1980. Geothermal System at 21°N, East Pacific Rise: Physical Limits on Geothermal Fluid and Role of Adiabatic Expansion; *Science*, v.207, p.1465-1469.
- Bischoff, J.L. and Dickson, F.W. 1975. Seawater-Basalt Interaction at 200°C and 50 Bars: Implications for Origin of Sea-Floor Heavy-Metal Deposits and Regulation of Seawater Chemistry; *Earth and Planetary Science Letters*, v.25, p.385-397.
- Booth, J.R. 1947. Mammoth Metals, June 1947, prepared for Algoma Ore Properties, Assessment Files Research Office, 2p.
- Boyd, D.G. 1899. Michipicoten Mining Division; Ontario Bureau of Mines, Report of the Bureau of Mines, v.8, p.100-105.
- 1900. Michipicoten Mining Division; Ontario Bureau of Mines, Report of the Bureau of Mines, v.9, p.112-118
- 1901. Michipicoten Mining Division; Ontario Bureau of Mines, Report of the Bureau of Mines, v.10, p.137-144.
- 1902. Michipicoten Mining Division; Ontario Bureau of Mines, Report of the Bureau of Mines, v.11, p.70-75.
- 1903. Michipicoten Mining Division; Ontario Bureau of Mines, Report of the Bureau of Mines, v.12, p.62-67.
- 1904. Michipicoten Mining Division; Ontario Bureau of Mines, Report of the Bureau of Mines, v.13, pt. 1, p.46-49.
- Brereton, W.E. 1983. Sample Results, Adina Property Wawa Area, Ontario, 1983, prepared for Welcome North Mines Ltd., Assessment Files Research Office, Toronto, 2p. with attachments.
- Brown, P.K. 1958. Memorandum Report, Lakemount Mines Ltd. Copper-Nickel Prospect, Hawk Junction, Ontario, prepared for the Anaconda Company, Assessment Files Research Office, Toronto, 3p.
- Brown, E.L. and Morrison, W.F. 1942. Geology of The Josephine Mine, Hydrothermal Origin of The Hematite; *Canadian Mining Journal*, v.63, p.5-9.
- Bruce, E.L. 1938. Regnery Molybdenite Deposit Hawk, Ontario; unpublished report dated October 1938, Mineral Deposit Inventory Record, Assessment Files Research Office, Toronto, 2p.
- 1940a. Geology of The Goudreau-Lochalsh Area; Ontario Department of Mines, Annual Report, v.49, pt. 3, p.1-50.
- 1940b. Goudreau-Lochalsh Area, District of Algoma, Ontario; Ontario Department of Mines, Map 49G, scale 1:31,680.

- Burwash, E.M., 1935a. The Michipicoten-Missinabi area, Ontario. Department of Mines Annual Report, v.44, p.1-26.
- 1935a. Geology of the Lochalsh-Missinabi area, Ontario. Department of Mines Annual Report, v.44, p.27-38.
- Calvert, T. 1983. Petrography and Geochemistry of an Archean Volcanic Sequence of The Josephine Area, Wawa, Ontario; unpublished B.Sc. Thesis, Brock University, St. Catharines, Ontario, 69p.
- Canadian Mining Journal 1956. Helen Mine Geology; p.78-87 in Algoma Ore Properties Limited, Canadian Mining Journal, v.77, p.75-130.
- Carter, W.E.H. 1902. The Mines of Ontario; Report of the Bureau of Mines, v.11, p.231-298.
- 1903. Mines of Eastern Ontario; Report of the Bureau of Mines, v.12, p.108-140.
- Cliff, W. 1928. Report on the Christie, Soulier, and O'Keefe Claims, prepared for Dome Mines, Assessment Files Research Office, 6p.
- Cole, T.G. 1983. Oxygen Isotope Geothermometry and Origin of Smectites in the Atlantis II Deep, Red Sea; Earth and Planetary Science Letters, v.66, p.166-176.
- Coleman, A.P., 1899. Copper regions of the upper lakes, Report of the Bureau of Mines. V.8 p.164-168.
- 1900. Copper and iron ranges of Ontario, Report of the Bureau of Mines, v.9, p.182-186.
- 1901. Iron ranges of the lower Huronian, Ontario Bureau of Mines, v.10, p.181-212.
- 1906. Iron Ranges of Eastern Michipicoten, Report of the Bureau of Mines, v.15, pt. 1 p.181-183.
- 1922. Glacial and Post-Glacial Lakes in Ontario; Publications of the Ontario Fisheries Research Laboratory, University of Toronto Studies, No. 10, 76p.
- Coleman, A.P. and Willmott, A.B. 1902. The Michipicoten Iron Region; Ontario Bureau of Mines, v.11, p.152-185.
- Collins, W.H. 1918. The Ore Deposits of Goudreau and Magpie - Hawk Areas in Michipicoten District, Ontario; Geological Survey of Canada, Summary Report 1918, pt.E, p.4-30.
- Collins, W.H. and Quirke, T.T. 1926. Michipicoten Iron Ranges; Geological Survey of Canada, Memoir 147, 175p.
- Cook, F.A. 1985. Geometry of the Kapuskasing Structure from a Lithoprobe Pilot Reflection Survey; Geology, v.13, p.368-371.
- Cooke, H.C. 1937. Structure of the Dore Series, Michipicoten District, Ontario; Royal Society of Canada, Transactions, Third Series, v.31, Section IV, p.69-80.

- Franklin, J.M., Lydon, J.W., and Sangster, D.F. 1981. Volcanic-associated Massive Sulfide Deposits; Economic Geology, 75th Anniversary V., p.485-627.
- Frey, E.D. 1986. Wawa Area: North Shore of Lake Superior, Field Trip Guidebook, XIIth. Inqua Congress, Ottawa 1987, 8p.
- 1987. Quarternary features and the scenery along the north shore of Lake Superior, XIIth INQUA Congress Field Excursion C-12, p.14-19
- Frohberg, M.H. 1933. Beitrage zur kennthis der turmalin fuhrenden gold quartzgane des Michipicoten Distriktes, Ontario; Mineralogische and Petrographische Mitteilungen, Bd. 44, Heft 5 Akademische Verlagsgesellschaft, Leipzig.
- 1934a. Geologic report on Grace Mine, Michipicoten Area, Ontario, prepared for Grace Gold Mining Co. Ltd., Assessment Files Research Office, Toronto, 17p.
- 1934b. Untitled report on geology of the Parkhill Mine, prepared for Parkhill Gold Mines Ltd., Assessment Files Research Office, Toronto, 21p.
- 1935. The Ore Deposits of the Michipicoten Area; Ontario Department of Mines, 44th Annual Report, pt.8, p.39-83.
- Gartner, J.F. and McQuay, D.F., 1979. Goudreau area (NTS 42C/SE) District of Algoma; Ontario Geological Survey, Northern Ontario Engineering Geogy Terrain Study 73, 14p. Accompanied by Map 5097, scale 1:100 000.
- Giblin, P.E. 1972. Asbestos Deposit at Lena Lake, Wawa area, Recommended Exploration Program, prepared for Algoma Ore Properties, Assessment Files Research Office, Toronto, 12p.
- Gilbert, G.S., and Jarvis, W.A. 1950. A report on a geological survey of that portion of the property of Algoma Ore Properties, Ltd., lying in Twp.28, Range 24, prepared for Algoma Ore Properties Ltd., Assessment Files Research Office, Toronto, 3p.
- Gibson, T.W., 1919. Statistical review of the mineral industry of Ontario for 1918, Ontario Bureau of Mines, v.28, pt.1, p.1-77
- Gittins, J., MacIntyre, J., and York, D. 1967. The Ages of Carbonatite Complexes in Eastern Canada; Canadian Journal Earth Sciences, v.4, p.651-655.
- Gledhill, T.L. 1927. Michipicoten Gold Area, District of Algoma; Ontario Department of Mines, 36th Annual Report, pt.2, p.1-49.
- 1934. Report on Soocana Mining Co. Ltd. Mine properties, prepared for Soocana Mining Company Ltd., Assessment Files Research Office, Toronto, 4p.
- 1937a. Report of the examination on Edina Syndicate Property Michipicoten Gold Area, Assessment Files Research Office, Toronto, 9p.

- Corkill, E.T., 1906, Mines in Ontario, Ontario Bureau of Mines, v.15, pt.1, p.47-67.
- 1907, Mines in Ontario, Ontario Bureau of Mines, v.16, pt.1, p.55-91.
- 1908, Mines in Ontario, Ontario Bureau of Mines, v.17, pt.1, p.58-94.
- 1909, Mines in Ontario, Ontario Bureau of Mines, v.18, pt.1, p.79-140.
- 1910, Mines in Ontario, Ontario Bureau of Mines, v.19, pt.1, p.78-130.
- Crobsy, W.O., 1902, Origin and relations of the auriferous veins of Algoma (western Ontario), *Technology Quarterly*, v.15, p.161-180.
- Deptuck, R., Squair, H., and Wierzbicki, V. 1982. Geology of the Detour Zinc-Copper Deposits, Brouillan Township, Quebec; p.319-342 in *Precambrian Sulphide Deposits (H.S. Robinson Memorial V.)*, Geological Association of Canada Special Paper 25, ___p.
- Dorfman, A. 1927. Minto Orebody, prepared for Cooper Gold Mines Ltd., Assessment Files Research Office, Toronto, 8p.
- Douglas, G.V. 1953. Pyritic Mineralization in the Goudreau Area of Algoma, Ontario; *Economic Geology*, v.49, p.310-316.
- Drury, J.J. 1950. Wilks-Arnott group of Mining Claims, Michipicoten District, Ontario, report for Jalore Exploration Company Ltd., Assessment Files Research Office, Toronto, 7p.
- Eden, G.F. 1980. The Geologic Setting of the Lucy Siderite Deposit; unpublished B.Sc. Thesis, Carleton University, Ottawa, Ontario, 59p.
- Edmond, J.M., Measures, C., Mangum, B., Grant, B., Schlatter, F.R., Collier, R., Hudson, A., Gordon, L.I., and Corliss, J.B. 1979. On the Formation of Metal-Rich Deposits at Ridge Crests; *Earth and Planetary Science Letters*, v.46, p.19-30.
- Eichmann, R., and Schidlowski, M. 1975. Isotopic Fractionation Between Coexisting Organic-Carbonate Pairs in Precambrian Sediments; *Geochimica et Cosmochimica Acta.*, v.39, p.585-595.
- Fabian, F.G. 19(?). Confidential Memorandum on the Parkhill Mine, Michipicoten District, Ontario Canada, Assessment Files Research Office, Toronto, 8p.
- Ferry, J.M. 1983. Mineral Reactions and Element Migration During Metamorphism of Calcareous Sediments from the Vassalboro Formation, South Central Maine; *American Mineralogist*, v.68, p.334-354.
- Finlow-Bates, T., and Large, D.E. 1978. Water Depth as Major Control on the Formation of Submarine Exhalative Ore Deposits; *Geologisches Jahrbuch, Reihe D.*, Heft 30, p.27-39.
- Foster, T.R. 1981. An Archean Pyroclastic and Epiclastic Sequence, Wawa-Abitibi Greenstone Belt; unpublished B.Sc. Thesis, Lakehead University, Thunder Bay, Ontario, 52p.



- 1937b. Report on an examination of the property of Soocana Mining Co. Ltd., prepared for Soocana Mining Company Ltd., Assessment Files Research Office, Toronto, 13p.
- 1939. Darwin Gold Mines Ltd., prepared for Darwin Gold Mines Ltd., Assessment Files Research Office, Toronto, 13p. with attachments.
- Goodwin, A.M. 1961. Genetic aspects of Michipicoten iron formation; Canadian Institute of Mining and Metallurgy, Transactions, v.LXIV, p.24-28.
- 1962. Structure, Stratigraphy and Origin of Iron Formations, Michipicoten Area, Algoma District, Ontario, Canada; Geological Association of America, Bulletin, v.73, p.561-586.
- 1963. Michipicoten Area Compilation Sheet; Ontario Department of Mines, Preliminary Geological Map P. 184, scale 1:31 630.
- 1964. Geochemical Studies at the Helen Iron Range; Economic Geology, v.59, p.684-718.
- 1966. The Relationship of Mineralization to Stratigraphy in the Michipicoten Area, Ontario; Geological Association of Canada, Special Paper 3, p.57-73.
- 1973. Archean Iron Formations and Tectonic Basins of the Canadian Shield; Economic Geology, v.68, p.915-933.
- Goodwin, A.M., Monster, J., and Thode, H.G. 1976. Carbon and Sulphur Isotope Abundances in Archean Iron Formations and Early Precambrian Life; Economic Geology, v.71, p.870-891.
- Goodwin, A.M. and Shklanka, R. 1967. Archean Volcano-Tectonic Basins: Form and Pattern; Canadian Journal of Earth Sciences, v.4, p.777-795.
- Goodwin, A.M. and Smith, I.E.M. 1980. Chemical Discontinuities in Archean Metavolcanic Terrains and the Development of Archean Crust; Precambrian Research, v.10, p.301-311.
- Goodwin, A.M., Thode, H.G., Chou, C.L., and Karkansis, S.N. 1985. Chemostratigraphy and origin of the late Archean siderite-pyrite-rich Helen Iron Formation, Michipicoten Belt, Canada; Canadian Journal of Earth Sciences, v.22, p.72-84.
- Gresen, R.L., 1967. Composition-volume relationships of metasomatism, chem. Geology, v.2, p.47-55
- Grout, F.F. 1926. Michipicoten Iron Ranges - Review; Economic Geology, v.21, p.813-817.
- Hajash, A. and Chandler, G.W. 1981. An Experimental Investigation of High Temperature Interactions between Seawater and Rhyolite, Andesite, Basalt, and Peridotite; Contributions to Mineralogy and Petrology, v.78, p.240-254.

- Hames, C.A. and Gallie, A.E. 1956. Lucy and Ruth Iron Ore Properties, Michipicoten District, Ontario; report for Sherritt Gordon Mines Ltd., Assessment Files Research Office, 29p.
- Hallof, P.G. 1956. Report on the geophysical surveys conducted on property near Jamestown, Ontario for New Kelore Mines Ltd., prepared for New Kelore Mines Ltd., Assessment Files Research Office, 6p.
- Hawley, J.E. 1942. Origin of some siderite, pyrite and chert deposits, Michipicoten District, Ontario; Royal Society of Canada, Transactions, Section 4, p.79-88.
- Haymon, R.M. 1983. Hydrothermal Deposition on the East Pacific Rise at 21°N; Journal of Geochemical Exploration, v.19, p.493-495.
- Hekinian, R., Rosendahl, B.R., and Natland, J.H. 1977. Ocean Crust Geothermal Processes: A Perspective from the Vantage of Leg 54 Drilling; Initial Reports of the Deep Sea Drilling Project, National Science Foundation - University of California, v.54, p.395-422.
- Hesse, W.A. 1934. Report on the Property of Atnel Mines Ltd. (Armstrong Property), Township 28, Range 24, District of Algoma, Michipicoten Mining Division, prepared for Atnel Mines Ltd., Assessment Files Research Office, Toronto, 13 p.
- 1935. Unpublished letter and drill logs sent to Atnel Mines Ltd., August 10, 1935; Assessment Files Research Office, Toronto.
- 1937. Report on the property of Michipicoten Gold Mines Ltd., prepared for Michipicoten Gold Mines Ltd., Assessment Files Research Office, 10p.
- 1938. Report on the Property of Ward Lake Gold Mines Ltd., prepared for Ward Lake Gold Mines Ltd., Assessment Files Research Office, Toronto, 15p.
- Hodder, R.W. 1959. Copper-Nickel Prospect of Lakemount Mines Ltd. near Michipicoten, Ontario, prepared for Southwest Potash, Assessment Files Research Office, Toronto, 4p.
- Holbrooke, G.L. 1936. Report on Atnel Mines Ltd., prepared for Erie Canadian Mines Ltd., Assessment Files Research Office, Toronto, 4p..
- Hopkins, P.E. 1930. Reed Group of mining claims, Hawk Junction, Ontario, Assessment Files Research Office, Toronto, 13p.
- Hoschek, G. 1967. Untersuchungen zum Stabilitätsbereich von Chloritoid and Staurolite; Contributions to Mineralogy and Petrology, v.14, p.123-162.
- Hough, J.H. 1961. Electromagnetic and Magnetometer Survey of the Kathleen Iron Prospect, A.C.R. Township 28, Range 24, prepared for Algoma Ore Properties Ltd., Assessment Files Research Office, Toronto, 3p.

- Huddert, J.V. 1961. Kathleen Iron Prospect, Twp.28, Range 24, prepared for Algoma Ore Properties Ltd., Assessment Files Research Office, Toronto, 4p..
- Irvine, T.N. and Baragar, W.R.A. 1971. A Guide to the Chemical Classification of the Common Volcanic Rocks; Canadian Journal of Earth Sciences, v.8, p.523-548.
- Jarvis, W.A. 1966. Comparison of Lucy and Ruth Reserve Estimates and Considerations to Effect of High Arsenic and Sulphur Values, prepared by Algoma Ore Properties Division, Assessment Files Research Office, Toronto, 3p.
- Jensen, L.S. 1976. A New Cation Plot for Classifying Subalkalic Volcanic Rocks; Ontario Division of Mines, Miscellaneous Paper 66, 22p.
- Johnston, C.S. 1956. Summary report on Lakemount Property of New Keltore Mines Ltd., prepared for New Keltore Mines Ltd., Assessment Files Research Office, Toronto, 7p.
- 1957. Summary report on Lakemount Property of New Keltore Mines Ltd., prepared for New Keltore Mines Ltd., Assessment Files Research Office, Toronto, 3p.
- Karkanis, S.N. 1978. Mineralogy, Stratigraphy, Micropaleontology, and Organic Geochemistry of Selected Archean Iron Formations of the Canadian Shield (abstract); p.431-432 in Program with Abstracts, Geological Association of Canada - Mineral Association of Canada - Geological Society of America, Joint Meeting, Toronto, ____ p.
- Karkhanis, S.N., Goodwin, A.M., and Ponnampetuma, C. 1980. Palaeobiology and Organic Geochemistry of Archean Helen Iron Formation, Michipicoten Area; Journal of Geological Society of India, v.21, p.1-9.
- Keith, M.L. and Weber, J.N. 1964. Carbon and Oxygen Isotopic Composition of Selected Limestones and Fossils; Geochimica et Cosmochimica Acta, v.28, p.1787-1816.
- Kerrich, R. and LaTour, T.E. 1981. Geochemical and $^{180}/^{160}$ Relations in the Michipicoten BIF: Evidence for Replacement and Alteration by Warm Marine Water; (abstract), Geology Department, University of Western Ontario, London, Ontario.
- Khan, M.A. 1972. Lena Lake asbestos prospect, prepared for Algoma Ore Properties, Assessment Files Research Office, Toronto, 2p.
- Kidder, S.J. and McCartney, G.C. 1946. Mining and Geology at the Helen Mine; American Institute of Mining and Metallurgy, Engineering Technical Publication 1971, p.1-24.
- Knight, C.W. 19(?). Report on Atnel Mines Ltd., prepared for Howey Gold Mines Ltd., Assessment Files Research Office, Toronto, 6p.
- Kuryliw, C.J. 1972. A report on Surlaga Gold Mines Ltd. Gold Property Wawa, Ontario, prepared for Ballinderry Explorations Ltd. and Surlaga Gold Mines Limited, Assessment Files Research Office, Toronto, 35p.
- Kustra, C.R. 1961. Memorandum in A.C.R. files regarding Atnel Mines Ltd. property, Assessment Files Research Office, Toronto.

- Lakefield Research 1952. Concentration of copper-nickel ore submitted by J.G. McCombe, Sault Ste. Marie, Ontario, prepared for Kelore Mines Ltd., Assessment Files Research Office, Toronto, 9p.
- Lamb, G.J. 1938. Report on property of Murray Algoma Mines Ltd. at Hawk Junction, Ontario, Twp.28, Range 24, Algoma District, prepared for Murray Algoma Mines Ltd.; Assessment Files Research Office, Toronto, 40p.
- Large, R.P. 1977. Chemical Evolution and Zonation of Massive Sulphide Deposits in Volcanogenic Terrain; *Economic Geology*, v.42, p.549-572.
- LaSeelleur, P.R. 1980. The Footwall Volcanic Rock of the Lucy Iron Formation, Michipicoten Area, Ontario; Unpublished B.Sc. Thesis, University of Western Ontario, London, Ontario; 104p.
- LaTour, T.E., Kerrich, R., Hodder, R.W., and Barnett, R.L. 1980. Chloritoid Stability in Very Iron-Rich Altered Pillow Lavas; *Contributions to Mineralogy and Petrology*, v.74, p.165-173.
- Lockwood, M.B. 1983. The Nature and Significance of Chloritoid in Footwall Basalt of the Josephine Iron Formation of the Michipicoten Area, Algoma District, Ontario; unpublished B.Sc. Thesis, University of Western Ontario, London, Ontario, 75p.
- Logan, W., 1847. Report of the Geological Survey of Canada for 1846-1847, p.10-13.
- 1863. The Huronian Series in *Geology of Canada*, 1863; Report in progress from its commencement to 1863, Geological Survey of Canada p.52-55.
- Loughrin, T.D. 1926. Memorandum, Assessment Files Research Office, Toronto, 2p.
- Lundberg, H. 1944. Report on the geophysical survey of Lakemount Mines Ltd., Algoma District, Province of Ontario, prepared for Lakemount Mines Ltd., Assessment Files Research Office, 12p.
- Macauley, T.N. 1962a. Geological report on Eleanor (Lena) Lake peridotite (Wagner's anomaly 13), Crown Township 29, Range 24 (FE), prepared for Algoma Ore Properties, Assessment Files Research Office, 2p.
- 1962b. Geological report on Wagner's Anomaly 14 (b) - A.C.R. Township 28, Range 24, prepared for Algoma Ore Properties Ltd., Assessment Files Research Office, Toronto, 2p.
- 1962c. Geological report on Lakemount Nickel-Copper Prospect, A.C.R. Township 28, Range 24, prepared for Algoma Ore Properties Ltd., Assessment Files Research Office, Toronto, 5p.
- 1962d. Geological report on Wagner's Anomaly 14 (a) - Crown Township 29, Range 24 (FE), prepared for Algoma Ore Properties, Assessment Files Research Office, Toronto, 2p.

- MacKenize, G.C., 1908. The iron and steel industry of Ontario; Ontario Bureau of Mines, v.17, p.190-342.
- MacLeod, G.W. 1927. Report on Minto and Jubilee, Michipicoten District, possibly prepared for Cooper Gold Mines Ltd., Assessment Files Research Office, Toronto, 30p.
- 1934. Report on the Michipicoten Property of the Engineers Holding Company Ltd., prepared for Engineers Holding Company Ltd., Assessment Files Research Office, Toronto, 3p.
- Mandziuk, Z.G. 1981. Molybdenite Lake Area; Ontario Geological Survey, Open File Report 5340, 71p.
- Mandziuk, Z.G. and Studemeister, P.A. 1981. Precambrian Geology of the Molybdenite Lake Area Covering Parts of Andre and Bailloquet Townships, Algoma District; Ontario Geological Survey, Preliminary Map 2406, Geological Series, Scale 1:15 840, Geology 1980.
- Marsden, R.W. 1948: The Mildred Iron Range, Michipicoten District, Ontario, prepared for Jalore Mining Company Ltd., Assessment Files Research Office, Toronto, 16p.
- Martin, W.C. 1953. Report on New Kelore Mines Limited, Hawk Junction-Michipicoten Area, Ontario, prepared for New Kelore Mines Ltd., Assessment Files Research Office, Toronto, 5p.
- Massey, N.W.D. 1985. Geology of Mishewawa Lake Area; Ontario Geological Survey, Open File Report 5532, 128p.
- Mather, W.B. 1939a. Preliminary report on Corinth Mines Property at Hawk Junction, Michipicoten District, Ontario, prepared for Corinth Mines Ltd., Assessment Files Research Office, Toronto, 5p.
- 1939b. Preliminary report on the east half of Corinth Mines Property at Hawk Junction, Michipicoten District, Ontario, prepared for Corinth Mines Ltd., Assessment Files Research Office, Toronto, 3p.
- Matheson, A.F. 1932. Michipicoten River Area, District of Algoma, Ontario, Canada; unpublished Ph.D. Thesis, University of Minnesota, Minneapolis, Minnesota, U.S.A., 96p.
- 1933. Michipicoten River Area, Ontario; Geological Survey of Canada, Summary Report, pt.D, p.1-21.
- May, W.T. 19(?). Report on Sandra Gold Mines Ltd., prepared for Mr. J.P. Manley, Assessment Files Research Office, Toronto, 8p. with attachments.
- McCombe, J.C. 1952. Report to Kelore Mines Ltd. on Nickel Copper Orebodies, Lakemount Property, prepared for Kelore Mines Ltd., Assessment Files Research Office, Toronto, 10p.

- McGill, G.E. and Shradly, C.H. 1986. Evidence for a Complex Archean Deformational History; Southwestern Michipicoten Greenstone Belt, Ontario; Proceedings of the Seventeenth Lunar and Planetary Science Conference, pt.1, Journal of Geophysical Research, v.91, No. B13, p.E281-E289.
- McGregor, J.A. 1968. The Lakemount nickel-copper deposit, Algoma District, Ontario, prepared for Amax Ltd., Assessment Files Research Office, Toronto, 12p.
- McKee, J.P. 19(?). The Michipicoten Iron district, Assessment Files Research Office, Toronto, 17p.
- 1950. Concluding letter, Wilks-Arnott Exploration, Assessment Files Research Office, Toronto.
- McMillan, D. 1981. The Significance of Chloritoid within the Footwall Volcanic Rock of the Helen Iron Range; unpublished B.Sc. Thesis, University of Western Ontario, London, Ontario; 56p.
- McQuay, D.F., 1980. Michipicoten area (NTS 41N/NE and part of 41N/NE), Districts of Algoma and Sudbury, Ontario Geological Survey, Northern Ontario Engineering Geology Terrain Study 79, 14p. Accompanied by Map 5010, scale 1:100 000.
- Means, A.H. 1914. Tourmaline-bearing gold-quartz veins of the Michipicoten District, Ontario; Economic Geology, v.9, p.122-135.
- Metcalf, H.S.K. 1952. The Eleanor-Arliss Lakes area, District of Algoma; unpublished report for Algoma Ore Properties, Assessment Files Research Office, Toronto, 8p.
- 1953. Report on visit to New Kelore Camp, prepared for Algoma Ore Properties Ltd., Assessment Files Research Office, Toronto, 2p.
- Michael, G.L. 1926. Incidents connected with the Michipicoten Gold Boom in 1896; Resident Geologist's Files, Ontario Ministry of Northern Development and Mines, Sault Ste. Marie, ____ p.
- Miller, W.G., 1903. Mines of northwestern Ontario, Ontario Bureau of Mines, v.12, p.78-79.
- Mitchell, R.H. and Janse, A.J.A. 1983. A Harzburgite-bearing Monchiquite from Wawa, Ontario; Canadian Mineralogist, v.20, p.211-216.
- Moore, E.S. 1931. Goudreau and Michipicoten Gold Areas, District of Algoma; Ontario Department of Mines, Annual Report, v.40, pt.4, p.1-54.
- 1943(?). Corinth Mines Ltd., prepared for Corinth Mines Ltd., Assessment Files Research Office, Toronto, 8p.
- 1946. Appendix: Lakemount Property, Township 28, Range XXIV; Ontario Department of Mines, Annual Report, v.55, pt.4, p.119-121.
- Moore, E.S., and Armstrong, H.S. 1946. Iron Deposits in the District of Algoma; Ontario Department of Mines, Annual Report, v.55, pt.4, p.1-118.

- Moore, J.G. 1965. Petrology of Deep-Sea Basalt Near Hawaii; *American Journal of Science*, v.263, p.40-52.
- Morton, R.L. and Nebel, M.L. 1983. Physical Character of Archean Felsic Volcanism in the Vicinity of the Helen Iron Mine, Wawa, Ontario, Canada; *Precambrian Research*, v.20, p.39-62.
- 1984. Hydrothermal Alteration of Felsic Volcanic Rocks at the Helen Siderite Deposit, Wawa, Ontario; *Economic Geology*, v.79, p.1319-1333.
- Murnane, R., and Claque, D.A. 1983. Nontronite from a Low Temperature Hydrothermal System on the Juan de Fuca Ridge; *Earth and Planetary Science Letters*, v.65, p.343-352.
- Neale, K.L. 1981. Sedimentology, Petrology, and Depositional Environment of Dore Sediments Above The Helen-Eleanor Iron Range, Wawa, Ontario; unpublished B.Sc. Thesis, McMaster University, Hamilton, Ontario, 54p.
- Nebel, M.L. 1982. Stratigraphy, Depositional Environment, and Alteration of Archean Felsic Volcanic Rocks, Wawa, Ontario; unpublished M.Sc. Thesis, University of Minnesota, Duluth, Minnesota, 114p.
- Newhall, C.G., and Melson, W.G. 1983. Explosive Activity Associated with the Growth of Volcanic Domes; *Journal of Volcanology and Geothermal Research*, v.17, p.111-131.
- ODM-GSC 1963a. Wawa, District of Algoma; ODM-GSC Map 2192G, scale 1:63 360.
- 1963b. Michipicoten Bay, District of Algoma; ODM-GSC Map 2191G, scale 1:63 360.
- Ojakangas, R.W., 1983. Clastic sedimentary rocks of the Michipicoten volcanic-sedimentary belt, Wawa, Ontario, in Workshop on a cross esection of Archean crust; Lunar and Planetary Institute Techincal Report 83-03, p.66-70.
- Ojakangas, R.W., 1985. Review of Archean clastic sedimewntation, Canadian Shield; felsic volcanic contributions to turbidite and alluvial fan - fluvial facies associated, *in* Evolution of Archean Supracrustal Sequences, Geological Survey of Canada Special Paper 28, p.23-47.
- Osler, P.F. 925. Report on Grace Mine and adjoining Properties - Michipicoten Area, Assessment Files Research Office, Toronto.
- Osterburg, M.W. 1982. Subaqueous Pyroclastic Volcanism in the Vicinity of the Helen Mine, Wawa, Ontario; unpublished M.Sc. Thesis, University of Minnesota, Duluth, Minnesota, 77p.
- Osterburg, M.W. and Morton, R.L. 1981, Subaqueous pyroclastic flow deposits in the vicintiy of the Helen Mine, Wawa, Ontario, *in* Abstracts and Proceedings of the 27th Annual Meeting , Institute on Lake Superior Geology.

- Oudkerk, G. 1983. The Extent of Chloritoid within the Rand No.2 Pyritic Iron Formation; unpublished B.Sc. Thesis, University of Western Ontario, London, Ontario, 38p.
- Parsons, A.L. 1915. The Productive Area of the Michipicoten Iron Ranges; Ontario Bureau of Mines, v.24, pt.1, p.185-215.
- Percival, J.A. 1983. High-grade Metamorphism in the Chapleau-Foley Area, Ontario; *American Mineralogist*, v.68, p.667-686.
- Percival, J.A., and Card, K.D. 1983. Archean Crust as Revealed in the Kapuskasing Uplift, Superior Province, Canada; *Geology*, v.11, p.323-326.
- Percival, J.A., and Krogh, T.E. 1983. U-Pb Zircon Geochronology of the Kapuskasing Structural Zone and Vicinity in the Chapleau-Foley Area, Canada; *Canadian Journal of Earth Sciences*, v.20, p.830-843.
- Reid, J.A. 1938. Report on the Property of the Parkhill Gold Mines Ltd., Gold Park, Ontario, prepared for Parkhill Gold Mines Ltd., Assessment Files Research Office, Toronto, 8p.
- Richter, D.H. 1952. Mineralogy and Origin of the Michipicoten Iron Ranges; unpublished M.Sc. Thesis, Queen's University, Kingston, Ontario, 96p.
- Riley, C. 1958. Township 28, Range 24, prepared for Algoma Central Railway, Assessment Files Research Office, Toronto, 1p.
- Robinson, A.H.A. 1932. Gold in Canada; Canada Department of Mines, Mines Branch, Publication 730, p.81-82.
- 1935. Gold in Canada; Canada Department of Mines, Mines Branch, Publication 769, p.110-112.
- Robinson, W.G. 1952. Lakemount Property of Kelore Mines Ltd.; unpublished letter from Frobisher Ltd. to Ventures Ltd., Assessment Files Research Office, Toronto, 1p.
- Rupert, R.J. 1975. McMurray Township and Parts of Surrounding Townships, District of Algoma; Ontario Division of Mines, Preliminary Map P.828, Geological Series, scale 1:15 815.
- 1979. Geology of McMurray Township and Parts of Surrounding Townships; Ontario Geological Survey, Open File Report 5283, 170p.
- 1980. Geologic and sampling report to the directors of Golden Goose Gold Mines Ltd. on the Deep Lake Mining Property, Wawa, Ontario, prepared for Golden Goose Gold Mines Ltd., Assessment Files Research Office, Toronto.
- Sage, R.P. 1979. Wawa Area, District of Algoma; p.48-53 in Summary of Field Work, 1979, by the Ontario Geological Survey, Miscellaneous Paper 90, 245p.
- 1980. Wawa Area, District of Algoma; p.47-50 in Summary of Field Work, 1980, by the Ontario Geological Survey, Miscellaneous Paper 96, 201p.

- 1983a. Geology of the Firesand River carbonatite complex; Ontario Geological Survey, Open File Report 5403, 136p.
- 1983b. Geology of the Slate Islands; Ontario Geological Survey, Open File Report 5435, 333p.
- Sage, R.P., Sawitsky, E., Turner, J., LeSeelleur, P., and Sagle, E. 1982. Precambrian Geology of McMurray Township, Wawa Area, Algoma District; Ontario Geological Survey, Preliminary Map P.2441, scale 1:15 815.
- Sage, R.P., Rebic, Z., Abercrombie, S., Neale, K., MacMillan, D., England, D., and Calvert, T. 1982a. Precambrian Geology of Chabanel Township, Algoma District; Ontario Geological Survey, Preliminary Map P.2439, scale 1:15 815.
- 1982b. Precambrian Geology of Esqueqa Township, Wawa Area, Algoma District, Ontario Geological Survey, Preliminary Map P.2440, scale 1:15 815.
- Sage, R.P., Sawitsky, E., Turner, J., Leeselleur, P. and Sagle, E. 1982. Precambrian Geology of Lastheels Township, Wawa Area, Algoma District; Ontario Geological Survey, Preliminary Map P.2442, scale 1:15 815.
- 1984. Josephine-Goudreau Area, District of Algoma; p. _____ in Summary of Field Work, 1984, Ontario Geological Survey, Miscellaneous Paper 119, 309p.
- Seyfried, W.E., Jr., and Bischoff, J.L. 1981. Experimental Seawater-Basalt Interaction at 300°C, 500 Bars: Chemical Exchange, Secondary Mineral Formation and Implications for the Transport of Heavy Metals; *Geochimica et Cosmochimica Acta*, v.45, p.135-147.
- Seyfried, W.E., Jr., and Mottl, M.J. 1982. Hydrothermal Alteration of Basalt by Seawater under Seawater-Dominated Conditions; *Geochimica et Cosmochimica Acta*, v.46, p.985-1002.
- Simard, L.R. 1952. Lakemount Property, prepared for Kelore Mines Ltd., Assessment Files Research Office, Toronto, 7p.
- Sinclair, D.G. 1934. Mines of Ontario in 1934; Ontario Department of Mines, Annual Report, v.44, pt.1, p.67-167.
- 1936. Mines of Ontario in 1935; Ontario Department of Mines, Annual Report, v.45, pt.1, p.77-188.
- 1937. Mines of Ontario in 1936; Ontario Department of Mines, Annual Report, v.46, pt.1, p.90-238.
- 1938. Mines of Ontario in 1937; Ontario Department of Mines, Annual Report, v.47, pt.1, p.80-249.
- 1939. Mines of Ontario in 1938; Ontario Department of Mines, Annual Report, v.48, pt.1, p.167-168.

- Skrechy, G. 1979. Preliminary report: Aldo Palma Option, prepared for Amax Minerals Exploration Ltd., Assessment Files Research Office, Toronto, 16p.
- 1981. A Petrological and Geochemical Study of a Precambrian Vein-Type Molybdenite Occurrence near Wawa, Ontario; unpublished B.Sc. thesis, Laurentian University, Sudbury, Ontario, 71p.
- Smith, P.E. and Farquhar, R.M. 1986. Assessment of the U-Th-Pb system in two Archean basalts - Evidence for the ancient enriched and depleted mantle (abstract); p.129. in Program with Abstracts, Geological Association of Canada - Mineralogical Association of Canada - Canadian Geophysical Union, Joint Annual Meeting, Ottawa.
- Streckeisen, A. 1976. To Each Plutonic Rock Its Proper Name; *Earth Science Reviews*, v.12, p.1-33.
- Studemeister, P.A. 1983. An Archean Felsic Stock with Peripheral Gold and Copper Occurrences, Abotossaway Township, District of Algoma, Ontario; unpublished Ph.D. Thesis, University of Western Ontario, London, Ontario, 501p.
- 1984a. Geological report on the Esquega Property, near Wawa, Ontario, prepared for J.Q. Resources Ltd., Assessment Files Research Office, Toronto, 16p.
- 1984b. The Distribution of Gold South of Wawa, Ontario, prepared for Dunraine Mines Ltd., Assessment Files Research Office, Toronto, 8p.
- 1985a. Gold-Bearing Veins around a Felsic Stock near Wawa, Ontario: Implications For Gold Exploration; *Canadian Institute of Mining and Metallurgy, Bulletin*, v.78, Number 874, p.43-47.
- 1985b. The greenschist metamorphism of Archean synvolcanic stocks near Wawa, Ontario Canada; *Journal of Metamorphic Geology*, v.3, p.79-90.
- Sullivan, R.W., Sage, R.P., and Card, K.D. 1985. U-Pb Zircon Age of the Jubilee Stock, Michipicoten Greenstone Belt near Wawa, Ontario; p.361-365 in *Current Research, pt.B, Geological Survey of Canada, Paper 85-1B*, ____ p.
- Summerhayes, M.W. 1928. Preliminary Report; Andargo Property, Michipicoten Ontario of Engineers Holding Company Ltd., prepared for Engineers Holding Company Ltd., Assessment Files Research Office, Toronto, 5p.
- Tanton, T.L. 1948. New Helen Mine, p.422-428 in *Structural Geology of Canadian Ore Deposits, Canadian Institute of Mining and Metallurgy Special Volume*, ____ p.
- Teare, J.H. 1936. Report on Edina Gold Syndicate Property, prepared for Edina Gold Syndicate, Assessment Files Research Office, Toronto, 3p. with attachments.
- Thode, H.G., and Goodwin, A.M. 1983. Further Sulphur and Carbon Isotope Studies of Late Archean Iron-Formations of the Canadian Shield and the Rise of Sulphate Reducing Bacteria; *Precambrian Research*, v.20, p.337-356.

- Thomas, D.A. 1984. Stratigraphy, Lithology, Petrography, and Depositional Environments of the Dore Sediments Proximal to the Lucy Iron Range, Wawa, Ontario; unpublished B.Sc. thesis, Carleton University, Ottawa, Ontario, 37p.
- Thorpe, R.I. 1982. Lead Isotope Evidence regarding Archean and Proterozoic Metallogeny in Canada; *Revista Brasileira de Geociencias*, v.12, No.1-3, p.510-521.
- 1987. Lead Isotope Data; p.46-55 in *Fieldtrip Guidebook, Geology and Stratigraphy of the Michipicoten Iron Formation*, Institute on Lake Superior Geology, Thirty-third Annual Meeting, Wawa, Ontario.
- Thurston, P.C., Siragusa, G.M., and Sage, R.P. 1977. *Geology of the Chapleau Area, Districts of Algoma, Sudbury, and Cochrane*; Ontario Division of Mines, Geoscience Report 157, 293p.
- Turek, A., Smith, P.E., and Van Schmus, W.R. 1982. Rb-Sr and U-Pb Ages of Volcanism and Granite Emplacement in the Michipicoten Belt - Wawa, Ontario; *Canadian Journal of Earth Sciences*, v.19, p.1608-1626.
- 1983. The evolution in time of the Wawa - Gamitagama Plutonic - Volcanic Terrain; Superior Province - northern Ontario; p.A70 in *Program with Abstracts, Geological Association of Canada - Mineralogical Association of Canada - Canadian Geophysical Union Annual Meeting*, v.8.
- 1984. U-Pb Zircon Ages and the Evolution of the Michipicoten Plutonic-Volcanic Terrane of the Superior Province, Ontario; *Canadian Journal of Earth Sciences*, v.21, p.457-464.
- Turner, F.J. 1968. *Metamorphic Petrology*, McGraw Hill Book Co., Toronto, 403p.
- Wagner, C.D. 1958(?). *Examination and Evolution of Regnery Metals Property of International Ranwick Ltd.*, prepared for International Ranwick Ltd., Assessment Files Research Office, Ontario Geological Survey, Toronto, 14p.
- Wagner, E.P. 1962. *Geophysical Report on Lakemount Test Survey, Twp.28, Range 24*, prepared for Algoma Ore Properties Ltd., Assessment Files Research Office, Toronto, 1p.
- Watson, I.M. 1983. *Examination report, Edina Gold Property, McMurray Twp., Ontario*, prepared for Nakusp Resources Ltd., Assessment Files Research Office, Ontario Geological Survey, Toronto, 17p. with attachments.
- Weeks, L.J. 1928. *Michipicoten River Map Area, Algoma District, Ontario*; Geological Survey of Canada, Summary Report, 1928, pt.C, p.1-11.
- Willmont, A.B. 1898. *Michipicoten Mining Division*; Ontario Bureau of Mines, Report, v.7, pt.2, p.184-206.

- Worona, R.M. 1982. The Chloritoid Alteration at the Josephine Mine, District of Algoma; unpublished B.Sc. Thesis, University of Waterloo, Waterloo, Ontario, 56p.
- Wyllie, P.J., and Huang, W.L. 1976. Carbonation and Melting Reactions in the System $\text{CaO} - \text{MgO} - \text{SiO}_2 - \text{CO}_2$ at Mantle Pressures, with Geophysical and Petrological Applications; Contributions to Mineralogy and Petrology, v.54, p.79-107.
- Young, W.L. 1951. The Lucy Orebody, Its Petrology, Structure and Origin; Michipicoten District, Ontario, Canada; unpublished M.Sc. Thesis, McGill University, Montreal, Quebec, 48p.
- 1953. The Iron-Bearing Formations of the Michipicoten Area, Ontario; unpublished Ph.D. Thesis, McGill University, Montreal, Quebec, 135p.
- Yule, G. 1980. Aldo Palma Molybdenite Property, Percussion Drill Report, Lastheels Township 945-02, NTS 41N/15 42C/2, prepared for Amax Minerals Exploration Ltd., Assessment Files Research Office, Toronto, 7p. with attachments.
- Zodrow, E. L. 1963. A combined, complete report: Geology, Geophysics on the Loonskin Lake Claims, AC. 4823-38, 4805-08, 4840-41 and 3211, prepared for Algoma Ore Properties Division, Algoma Steel Corporation Ltd., Assessment Files Research Office, Toronto.

Table 1: Table of Lithologic Units for the Michipicoten
Supracrustal Belt, Wawa, Ontario

Cenozoic

Pleistocene and Recent

Till, sand, gravel boulders, clay, swamp and lake
deposits

Precambrian

Late Proterozoic

Firesand carbonatite

Lamprophyre dikes

Intrusive Contact

Diabase dike

Intrusive Contact

Early Precambrian

Granodiorite, quartz diorite, quartz monzonite
granite

Intrusive Contact

Intermediate to mafic pillowed and massive volcanics;
rare polymictic breccias. Intermediate to felsic
volcanics; tuffs, lapilli tuff, breccias, quartz
feldspar crystal tuffs.

Conformable Contact

Dore' Metasediments

Lithic wacke, wacke conglomerate, siltstone argillite

Intrusive Contact

Gutcher Lake Stock

Trondhjemite, granodiorite, tonalite

Conformable Contact

Intermediate to mafic metavolcanics

Conformable Contact

Michipicoten iron Range

Siderite, pyrite, chert-pyrite,
 chert-wacke-magnetite, chert, argillite-pyrite

Conformable Contact

Intermediate to felsic metavolcanics. Massive flows,
 spherulitic flows, tuffs, lapilli tuffs, quartz
 feldspar crystal tuffs, flow banded flows, polymictic
 breccias

Intrusive Contact

Jubilee Stock

Diorite, quartz diorite, granodiorite, quartz
 feldspar porphyry

Conformable Contact(?)

Jubilee Tuffs

Intermediate composition tuff, feldspar crystal tuff,
 polymictic breccias

Conformably Contact(?)

Intermediate to mafic massive and pillowed mafic
 volcanics

Conformably Contact(?)

Iron formation, chert, chert-pyrite, chert-magnetite,
 chert-graphite

Conformably Contact(?)

Intermediate to felsic tuffs. Tuffs, lapilli tuffs,

rare breccias, quartz-feldspar crystal tuffs. Rare intermediate to mafic tuffs.

Intrusive Contact

Hawk Lake Granite

Granodiorite, quartz monzonite, trondhjemite, quartz + feldspar porphyry.

Conformably Contact(?)

Intermediate to mafic metavolcanics. Flows commonly massive, pillows uncommon. Rare spinifex and polysutured texture.

TABLE 3: SAMPLE DESCRIPTIONS OF ANALYZED IRON FORMATION USED
IN COMPOSITE SECTION OF MICHIPICOTEN IRON FORMATION
(Sample Interval 1.3 m).

<u>Sample</u>	<u>Lithology</u>
L1	Fine grained schistose mafic metavolcanic
L2	Fine grained schistose mafic metavolcanic
L3	Fine grained schistose mafic metavolcanic
L4	Fine grained schistose mafic metavolcanic with amygdaloids
L5	Fine grained schistose mafic metavolcanic with amygdaloids
L6	Fine grained schistose mafic metavolcanics
L7	Fine grained schistose mafic metavolcanics
L9	Fine grained schistose mafic metavolcanics
L10	Fine grained massive siderite with arsenopyrite at volcanic-iron formation contact; arsenopyrite crystals up to 5 mm
L11	Fine grained massive siderite with arsenopyrite crystals up to 1 cm
L13	Coarse grained ankerite with quartz vein
L12	Fine grained massive siderite with needle- like arsenopyrite crystals up to 1 cm. Rock is 2 to 3% arsenopyrite
L12B	Coarse grained ankerite and quartz vein with trace pyrite
L13	Fine grained massive siderite with 2 to 3% arsenopyrite in crystals up to 8 mm
L14	Framboidal pyrite with minor siderite. Sample 60% pyrite from band 0.6 m wide. Two to 4% arsenopyrite present.

Pyrite and up to 1% fine grained arsenopyrite
L15B Coarse grained ankeroite and quartz vein

L16 Fine grained massive siderite with 45%
framboidal pyrite

L17 Fine grained siderite with thin laminae of
chert 0 to 8 mm wide.

L18 Fine grained siderite with irregular
concentrations of arsenopyrite that form up to 5% of
rock.

L19 Fine grained massive siderite with 5 to 10%
fine grained pyrite

L20 Fine grained siliceous siderite with 15 to 20%
disseminated and clotty pyrite.

L21 Fine grained siliceous siderite with 10 to 15%
pyrite.

L22 Fine grained siliceous siderite with 30 to 40%
fine grained pyrite. Some pyrite occurs as
elliptical structures up to 1 cm in diameter.

L23 Fine grained siliceous siderite with 45 to 55%
fine grained pyrite. Pyrite commonly occurs as
elliptical structures up to 1 cm in diameter.

L24 Contact between massive and banded siliceous
siderite. Fine grained greenish siderite;
disconformity may be present. Above siderite a fine
grained siliceous ash.

24A Siliceous ash

24B Siliceous siderite

L25 Banded iron formation. Bands of siliceous
siderite and siliceous pyrite-siderite. Fine-grained
pyrite-bearing bands may contain up to 30% siderite.
Bands from barely discernible to 3 cm wide.

L27^{us}. Banded pyrite and chert with minor siderite.

Pyrite bands from barely discernible to 1 cm and chert bands from barely discernible to 3 cm.

L28 Banded chert; change in rock type and weathering suggests low siderite content. Possible internal contact gradational over several centimetres.

28A On lower side of gradational contact. Rock contains 5 to 10% fine grained disseminated pyrite. Banding barely discernible to 4 cm.

28B Upper part of gradational contact. While to buff sugary chert with minor brown sideritic chert bands with up to 5% pyrite in bands.

L29 Sideritic sugary dark grey chert band 12 cm wide.

L30 Laminated dark grey fine grained chert

L31 Thinly laminated chert with laminations barely discernible to 2 cm. Light brown weathering. Up to 5% pyrite in thin bands.

L32 Banded chert with bands barely discernible to 2 cm. Chert buff to white in color, sugary texture.

L33 Banded chert with light brown bands alternating with white, sugary textured bands. Trace pyrite.

L34 Banded chert with barely discernible bands to 3 cm. Light brown bands alternate with buff to white bands. Trace to 1% pyrite.

L35 Banded chert with dark grey bands alternating with buff to white bands. Sugary textured. Trace pyrite in dark bands.

- L36 Banded chert with dark grey bands alternating with buff to white bands. Chert is sugary. Trace of pyrite in dark bands.
- L37 Banded chert with dark grey chert alternating with buff bands. Banding from barely discernible to 3 cm. Dark bands appear argillaceous.
- L38 Banded chert with dark grey to black chert bands alternating with white buff chert. Banding from barely discernible to 4 cm.
- L39 Banded chert with dark grey to black chert alternating with white to buff chert. Chert is sugary and banding varies from barely discernible to 4 cm.
- L40 Brecciated banded chert. Same as L39
- L41 Same as L40
- L42 Banded chert with dark grey to black bands alternating with buff coloured chert. Banding barely discernible to 5 cm. Chert sugary textured.

ELEANOR SECTION

- E1 Graphitic argillite immediately below overlying mafic flow. Ten to 15% fine grained pyrite.
- E2 Graphitic argillite with pyrite concretions up to 3 cm in diameter. Pyrite 10 to 15% of rock.
- E3 Graphitic argillite with concretions up to 8 mm. Pyrite occurs as fine grained laminae or as discontinuous streaks. Pyrite 5 to 10% of the rock.
- E4 Siliceous graphitic argillite with 10 to 15% fine grained pyrite. Pyrite in discontinuous streaks up to 2 mm wide.
- E5 Same as E4

E8 FINE grained black graphitic chert with occasional
1 to 3 mm wide laminae of pyrite.

E9 Fine grained black graphitic chert with 5%
disseminated pyrite and occasional pyrite laminae.

Table 4: Minor Element Chemistry of Iron Formation Samples Used in Composite Section of Michipicoten Iron Formation.

Sample #	As (pptm)	Au (ppb)	B (ppm)	Ba (ppm)	Bi (pptm)	Ce (ppm)	Co (ppm)
L1	1120	9	26	280	2	175	12
L2	140	6	28	150	3	160	31
L3	60	N.A.	50	200	2	280	17
L4	25	N.A.	12	210	1	<35	13
L5	30	<2	110	190	5	<35	13
L6	30	<2	30	170	1	<35	18
L7	210	<2	52	150	<1	175	36
L8	210	12	28	140	<1	<35	12
L9	250	34	58	140	<1	135	6
L10	>10,000	2	830	40	13	95	6
L11	>10,000	5	190	30	3	50	<5
L11B	420	6	55	90	<1	<35	<5
L12	>10,000	4	550	60	9	60	<5
L12B	3600	3	130	70	<1	<35	<5
L13	>10,000	3	420	40	25	65	8
L14	8,000	290	440	30	40	75	116
L15	>10,000	11	123	40	26	50	10
L15B	190	<2	18	60	2	<35	<5
L16	>10,000	95	230	20	16	55	81
L17	6,400	<2	64	30	4	<35	<5
L18	>10,000	18	110	120	49	<35	24
L19	1,300	3	12	<10	2	55	<5
L20	3300	6	28	20	6	40	8
L21	5300	<2	22	10	10	2	55
L22	>10,000	<2	20	30	16	50	9
L23	2400	90	40	10	2	65	57
L24A	1740	<2	14	40	3	45	<5
L24B	120	4	95	210	<1	<35	<5
L25	>10,000	21	175	110	18	55	66
L26	900	3	40	30	2	35	14
L27	15	14	45	60	<1	40	<5
L28	2000	<2	17	20	3	<35	<5
L28B	160	<2	35	20	2	<35	5
L29	1120	<2	25	50	1	<35	<5
L30	100	<2	18	20	<1	<35	<5
L31	880	<2	27	20	1	<35	<5
L32	9300	<2	32	30	2	45	26
L33	120	<2	24	40	<1	<35	<5
L34	550	6	28	80	1	<35	<5
L35	800	6	95	120	<1	<35	<5
L36	140	<2	40	50	<1	<35	<5
L37	350	<2	24	50	<1	<35	<5
L38	350	<2	36	40	<1	45	<5
L39	40	<2	55	20	<1	<35	<5
L40	1520	<2	50	20	<1	<35	7
L41	5100	<2	16	70	2	<35	9
L42	6500	3	26	70	8	35	24
E1	270	4	65	670	<1	<35	9
E2	1280	2	250	490	5	<35	49
E3	90	<2	30	150	<1	<35	<5

E4	900	17	70	80		8	<35	34
E5	1100	16	110	170	7	<35	33	
E6	820	6	140	110	4	<35	32	
E7	400	<2	60	60	<1	<35	<5	
E8	1660	8	50	90	5	<35	49	
E9	1640	<2	650	50	2	<35	7	

<2 means less than two

Sample #	Cr (ppm)	Cu (ppm)	Ga (ppm)	Li (ppm)	Nb (ppm)	Ni (ppm)	Mn (ppm)
L1	180	6	13	30	40	47	1840
L2	87	17	10	16	30	40	9950
L3	163	8	17	30	50	33	2000
L4	138	7	7	26	13	28	3300
L5	154	10	13	36	11	28	1840
L6	153	28	13	36	15	50	3950
L7	91	22	9	32	30	81	8300
L8	83	22	8	22	9	35	8850
L9	77	54	11	28	25	23	7200
L10	5	10	5	<3	9	<5	>10,000
L11	5	5	4	4	3	<5	>10,000
L11B	<5	5	<1	<3	<1	<5	>10,000
L12	9	6	6	<3	4	<5	>10,000
L12B	<5	6	<1	<3	<1	<5	>10,000
L13	15	7	6	10	5	16	>10,000
L14	6	44	6	4	3	72	9350
L15	7	13	5	6	4	31	>10,000
L15B	<5	30	<1	<3	<1	16	>10,000
L16	6	295	9	4	3	74	>10,000
L17	<5	<5	<1	<3	<1	<5	>10,000
L18	19	30	10	9	3	31	>10,000
L19	<5	6	1	<3	3	<5	>10,000
L20	<5	<5	1	<3	3	11	>10,000
L21	<5	16	1	<3	3	7	>10,000
L22	<5	9	2	<3	2	21	>10,000
L23	<5	14	2	<3	3	39	8300
L24A	13	24	4	3	3	22	>10,000
L24B	<5	8	22	33	4	8	350
L25	28	46	24	16	4	76	4950
L26	9	28	3	4	<1	22	6900
L27	17	46	5	8	2	12	9500
L28	5	6	1	<3	<1	<5	8350
L28B	<5	24	2	<3	<1	13	7250
L29	6	24	2	<3	<1	<5	5650
L30	<5	<5	1	<3	<1	<5	6600
L31	6	6	1	<3	<1	8	6400
L32	8	6	2	<3	2	<5	>10,000
L33	<5	5	1	<3	<1	<5	>10,000
L34	<5	18	2	<3	<1	<5	5700
L35	37	16	2	<3	<1	<5	800
L36	<5	12	1	<3	<1	<5	1010
L37	<5	28	1	<3	<1	<5	5550
L38	9	18	2	<3	<1	<5	9800
L39	<5	<5	1	<3	<1	<5	505
L40	<5	44	1	3	<1	12	1620
L41	<5	121	1	<3	<1	11	1920
L42	7	240	4	3	<1	39	8850
E1	19	5	24	3	3	8	22
E2	149	38	19	<3	4	47	195
E3	23	14	4	<3	<1	8	48
E4	29	25	2	<3	<1	30	186

E5	36	28	3	<3	<1	24		310		
E6		20		14	3		<3		<1	27
E7	22	6	1	<3	<1	<5	145			102
E8	15	21	2	<3	<1	30	405			
E9	20	60	5	<3	<1	15	4900			

Sample #	Pb (ppm)	Sb (pptm)	Sc (ppm)	Se (ppb)	Sn (pptm)	Sr (ppm)	V (ppm)
L1	147	52	25	<30	4	200	190
L2	167	23	21	90	3	130	120
L3	145	29	30	<30	4	195	185
L4	67	39	17	<30	2	205	135
L5	65	37	13	<30	12	185	135
L6	120	35	15	<30	13	195	150
L7	61	33	18	50	2	130	110
L8	71	34	14	<30	3	140	95
L9	80	100	16	30	2	185	125
L10	22	82	6	270	<1	23	35
L11	<10	42	2	105	2	35	25
L11B	45	4	3	<30	2	115	12
L12	<10	42	2	105	12	18	30
L12B	31	4	3	<30	<1	135	12
L13	20	90	4	1500	5	30	40
L14	97	594	3	2325	7	11	35
L15	46	82	4	420	<1	19	30
L15B	106	7	2	330	9	45	13
L16	56	147	1	1320	6	15	35
L17	126	21	<1	<30	4	13	13
L18	37	116	3	420	8	55	40
L19	30	6	2	30	5	9	25
L20	34	21	2	210	9	25	25
L21	24	21	3	120	4	13	25
L22	21	44	2	157	6	14	25
L23		54	629	2		600	
L24	<10	38	4	600	4	18	30
L24B	42	29	3	195	23	150	30
L25	82	903	2	2025	10	35	55
L26	27	92	<1	675	6	10	30
L27	10	32	<1	600	9	13	40
L28	37	40	<1	600	1	6	13
L28B	19	35	<1	1275	5	6	17
L29	33	96	<1	420	6	13	17
L30	33	20	<1	30	2	12	13
L31	38	61	<1	780	5	5	12
L32	84	78	2	840	8	8	25
L33	61	15	<1	37	4	6	14
L34	19	18	<1	930	4	10	10
L35	200	280	<1	150	42	8	5
L36	21	26	<1	132	3	12	3
L37	48	25	<1	157	4	16	16
L38	97	24	<1	75	7	15	20
L39	141	23	<1	52	2	8	3
L40	102	56	<1	862	6	24	10
L41	84	122	<1	1950	3	25	14
L42	48	192	<1	6000	7	23	30
E1	98	35	12	1270	15	55	60
E2	95	251	13	3340	23	90	90
E3	81	62	1	352	12	14	14
E4	151	376	<1	4300	12	9	10

E5	200	365	<1	2400	48	12	7
E6.		144	230		<1	2000	
E7	205	142	<1	232	18	9	2
E8	143	268	<1	4570	24	9	6
E9	77	170	<1	600	20	60	9

17

9

9

Sample #	Y (ppm)	Zn (ppm)	Zr (ppm)
L1	11	48	110
L2	9	104	60
L3	12	37	110
L4	6	44	80
L5	4	38	85
L6	5	76	80
L7	10	76	60
L8	6	77	50
L9	11	60	80
L10	8	82	16
L11	6	48	15
L11B	13	48	<1
L12	6	50	25
L12B	12	46	<1
L13	7	59	45
L14	3	31	30
L15	5	50	17
L15B	9	33	<1
L16	4	44	15
L17	<2	24	5
L18	11	47	25
L19	2	52	7
L20	6	33	6
L21	<2	44	8
L22	5	34	7
L23	3	34	16
L24	5	131	16
L24B	6	12	150
L25	4	37	65
L26	2	52	20
L27	4	96	35
L28	<2	54	6
L28B	<2	44	6
L29	<2	44	9
L30	2	40	5
L31	<2	26	5
L32	<2	60	8
L33	<2	58	5
L34	<2	30	15
L35	<2	14	5
L36	<2	32	4
L37	2	70	9
L38	3	62	7
L39	<2	26	2
L40	<2	40	4
L41	<2	68	2
L42	3	160	9
E1	16	24	165
E2	7	156	80
E3	<2	37	17
E4	<2	152	9

E5	<2	130	6
E6	<2	280	9
E7	<2	14	5
E8	<2	1260	4
E9	2	41	6

Table 5: Gold & Boron Contents Within Cycle 2 - Mafic to Intermediate Metavolcanics

Sample #	Element	
	Au (ppb)	B (ppm)
80RPS - 0012	<2	<5
- 0013	<2	<5
- 0015	<2	5
- 0016	6	33
- 0017	<2	<5
- 0018	N.A.	<5
- 0018D	N.A.	<5
- 0019	15	11
- 0020	<2	<5
- 0021	<2	11
- 0022	<2	<5
- 0024	<2	18
- 0027	<2	49
- 0028	4	10
- 0029	2	<5
- 0030	3	15
- 0031	<2	<5
- 0031D	<2	N.A.

Table 6: TABULATED DATA FOR RADIOACTIVE CARBONATE DIKES ALONG HIGHWAY 101.

Dike No.	Station No.	CPM-dike	CPM-WR	Strike	Dip	Width	U(ppm)				
Th(ppm)	Ce(ppm)	Nd(ppm)									
RA-1	111-2B	7500	1800	015o	55oS	15cm	24	70	560	300	
RA-2	111-23	8000	1500	345o	76oW	5cm	NA	-	-	-	
RA-3	111-24C	15000	2000	000o	9oW	40cm	9	260	40	230	
RA-4	111-25A	20000	2000	135o	50oW	15cm	8	420	380	190	
RA-5	111-27	15000	2500	145o	50oW	Braided	NA	-	-	-	
RA-6	111-31	4000	1500	070o	82oS	5cm	<1	10	40	30	
RA-7	111-32	3000	2000	345o	71oN	-	NA	-	-	-	
RA-81	111-33	4500	2000	150o	69oS	Braided	11	-	70	660	
360											
RA-82	111-34B	15000	2000	350o	52oE	Braided	6	120	1520	700	
RA-9	111-44	15000	1500	150	80N	20cm	10	230	3640	1540	
RA10	111-46	4500	1000	-	-	-	NA	-	-	-	
NA11	90-8	2100	1700	130	65N	12cm	NA	-	-	-	
RA12	90-13C	3000	2000	290?	-	-	2	30	1800	550	
	90-13D	19000	1500	320	80S	4-6cm	-	21	70	4940	1430
RA13	90-30B	12000	2500	-	-	-	8	280	1400	580	
RA14	90-51B	5500	3500	100	83N	4-5cm	-	7	30	320	160
RA15	90-53	28000	3000	260	90	12cm	NA	-	-	-	-
RA16	90-64	5700	3000	-	-	-	NA	-	-	-	-
RA17	90-37C	15000	4000	105	80S	braided	4	220	500	280	

NA = not analyzed, CPM = counts per minute, WR = wall rock

Table 7: Mineral Chemistry of Chloritoid-bearing Intermediate to Mafic Flows Below Josephine Iron Range, (Lockwood, 1983, p.66-75).

Chlorite Analyses

Sub Group SI Al / Al Ti MG FE MN CR NA CA K / O /

	1	2	3	4	5	6	7
SiO2	24.34	23.87	23.41	23.45	23.77	24.14	23.39
TiO2	.12	.08	.14	.05	.10	.13	.08
A2O3	22.24	22.49	22.63	23.33	22.67	23.08	22.27
C2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FeO	31.08	31.15	30.89	32.30	31.36	31.91	30.80
MnO	.14	.11	.04	.19	.12	.17	.07
MgO	9.48	9.60	9.49	9.48	9.51	9.56	9.46
CaO	0.00	0.00	0.01	0.00	0.00	0.01	0.00
Na2O	0.00	0.00	0.00	0.17	.04	.12	.03
K2O	0.00	0.00	0.00	.07	.02	.05	.01
SUM	87.40	87.30	86.61	89.04	87.59	89.17	86.00

1 Sample 296 chlorite

5 Average

2 another chlorite

6 Average plus sigma

3

7 Average minus Sigma

4

Mica Analyses

	1	2	3	4	5	6	7
SiO2	47.88	47.32	49.73	48.14	48.27	49.16	47.37
TiO2	.01	.24	0.00	.04	.07	.17	.03
A2O3	37.68	37.74	38.04	38.27	37.93	38.17	37.69
C2O3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FeO	.14	.19	.02	.14	.12	.19	.06
MnO	.05	0.00	0.00	0.00	0.01	.03	.01
MgO	.07	.18	.02	0.00	.07	.14	.00
CaO	.33	.12	.24	.35	.26	.35	.17
Na2O	6.14	4.73	5.16	6.68	5.68	6.45	4.91
K2O	1.84	4.10	1.36	.55	1.96	3.28	.65
SUM	94.14	94.62	94.57	94.17	94.37	97.94	90.81

1 Sample 6-293 Mica

5 Average

2

6 Average plus sigma

3

7 Average minus sigma

4

	1	2	3	4	5	6	7	8
SiO2	46.03	46.46	48.40	47.98	48.30	47.43	48.42	
46.44								
TiO2	.09	.07	.04	.07	.03	.06	.08	
.04								
A2O3	35.24	34.44	34.71	37.31	36.85	35.71	36.87	
34.55								

C203	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00							
FEO	.51	.82	.44	.27	.34	.50	.69
.30							
MNO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00							
MGO	.24	.19	.32	.12	.10	.19	.27
.11							
CAO	.37	.09	.07	.16	.13	.16	.27
.06							
NA2O	1.86	1.86	2.02	4.75	5.39	3.18	4.74
1.62							
K2O	9.05	9.21	8.65	4.30	3.25	6.89	9.47
4.32							
SUM	93.49	93.14	94.65	94.96	94.40	94.13	100.82 87.44

1 Sample 296 Mica
 2
 3

5
 6 Average
 7 Average plus sigma
 8 Average minus sigma

(cont. Table 7)

Mica Analyses

Sub Group SI Al / Al Ti MG FE MN CR NA CA K / O /

	1	2	3	4	5	6	7	8
S102	49.10	47.41	46.05	47.78	47.72	48.63	47.78	
	48.75							
T102	0.00	0.00	.02	.01	.04	.00		
	.01							
A203	36.19	37.80	39.76	37.87	38.27	38.11	38.00	
	39.04							
C203	0.00	0.00	0.00	0.00	0.00	.17		
	.03							
FE0	.12	0.00	0.00	.12	.05	.07		
	.06							
MNO	0.00	0.00	0.00	0.00	0.00	.02		
	.00							
MG0	.04	.01	.02	.04	.02	0.00		
	.02							
CA0	.14	.32	3.61	.84	.34	.25		
	.92							
NA20	5.00	6.78	5.04	8.23	7.01	5.50		
	5.93							
K20	6.08	1.34	1.68	1.22	.66	2.38		
	2.23							
SUM	96.67	93.66	95.18	94.11	94.11	95.13	94.98	
	100.96							

1 Sample 7-412 Mica

5

2 Another Mica

6

3

7 Average

4

8 Average plus sigma

9

S102	46.82
T102	.00
A203	36.96
C203	.04
FE0	.01
MNO	-.00
MG0	.01
CA0	-.31
NA20	5.13
K20	.43
SUM	89.00

9 Average minus sigma

(cont. Table 7)

Chloritoid Analyses

	1	2	3	4	5	6	7	
S102	25.65	25.93	25.69	25.54	25.70	25.84	25.56	
Ti02	.05	.04	.04	.06	.05	.06	.04	
A203	39.58	39.06	42.02	41.33	40.50	41.71	39.28	
C203	0.00	0.00	0.00	.06	.02	.04	-	
.01								
FEO	23.21	23.11	24.76	24.48	23.89	24.63	23.15	
MNO	.95	1.07	1.04	.83	.97	1.07	.88	
MGO	3.42	3.03	2.59	2.71	2.94	3.26	2.62	
CAO	0.00	.02	.03	.01	.02	.03	0.00	
NA20	0.00	.15	0.00	0.00	.04	.10	-.03	
K20	0.00	.02	0.00	0.00	.01	.01	-.00	
SUM	92.86	92.43	96.17	95.02	94.12	96.75	91.49	

1 Sample 6-293 Chloritoid
 2
 3
 4

5 Average
 6 Average plus sigma
 7 Average minus sigma

	1	2	3	4	5	6	7	
S102	25.31	24.53	25.56	25.21	25.15	25.53	24.77	
Ti02	.02	.05	.11	.04	.06	.09	.02	
A203	41.92	40.14	41.59	42.46	41.53	42.39	40.67	
C203	.05	.03	0.00	0.00	.02	.04	-.00	
FEO	26.64	26.85	26.72	27.07	26.82	26.98	26.66	
MNO	.43	.41	.29	.32	.36	.42	.30	
MGO	1.51	1.69	1.63	1.57	1.60	1.67	1.53	
CAO	.02	.02	0.00	0.00	.01	.02	.00	
NA20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
K20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
SUM	95.90	93.72	95.90	96.67	95.55	97.14	93.95	

1 Sample 296 chloritoid
 2
 3
 4

5 Average
 6 Average plus sigma
 7 Average minus sigma

	1	2	3	4	5	6	7	8	
S102	25.45	25.24	24.59	25.15	25.66	25.20	25.22		
25.54									
Ti02	.09	.04	.07	.06	.05	.05	.00		
.08									
A203	43.34	42.46	42.49	38.74	38.96	37.88	40.6		
42.81									

C203	.02	0.00	0.00	0.00	0.00	0.00	0.00
.01							
FEO	25.09	25.05	25.93	25.50	25.38	25.73	25.45
25.76							
MNO	.51	.62	.62	.43	.49	.59	.54
.61							
MGO	2.15	2.22	2.04	2.35	2.18	2.18	2.19
2.28							
CAO	0.00	0.00	.01	0.00	0.00	0.00	.00
.01							
NA20	0.00	0.00	.43	.19	0.00	0.00	.10
.27							
K20	0.00	0.00	.01	0.00	0.00	0.00	.00
.01							
SUM	96.65	95.63	96.19	92.42	92.72	91.63	94.21
97.37							

1 Sample 6-404

2

3

4 Sample 6-404 Matrix

5 Vein

6 Another vein

7 Average

8 Average plus sigma

(cont. Table 7)

Chloritoid Analyses

9

SiO ₂	24.89
TiO ₂	.04
Al ₂ O ₃	38.48
CaO	-.00
FeO	25.13
MnO	.47
MgO	2.09
CaO	-.00
Na ₂ O	-.06
K ₂ O	-.00
SUM	91.04

9 Average Minus Sigma

(cont. Table 7)

Chloritoid Analyses

Sub Group SI Al / Al Ti MG FE MN CR NA CA K / O /

	1	2	3	4	5	6	7	8
SiO2 25.13	25.32	26.31	25.54	25.78	25.67	25.63		
26.00								
TiO2 .04	0.00	.07	.09	.03	.11	.06		
.09								
Al2O3 41.49	42.48	42.45	42.26	42.41	42.38	42.25		
42.59								
Cr2O3 0.00	0.00	0.00	.01	.02	.05	.01		
.03								
FeO 24.29	23.89	25.02	24.62	24.80	24.84	24.58		
24.96								
MnO .87	.63	.73	.68	.76	.61	.71		
.80								
MgO 2.17	2.46	2.05	2.52	2.30	2.18	2.28		
2.45								
CaO 0.00	0.00	0.00	0.00	0.00	0.00	0.00		
0.00								
Na2O .11	.04	0.00	0.00	.04	0.00	.03		
.07								
K2O 0.00	0.00	0.00	.01	0.00	0.00	.00		
.01								
SUM 94.10	94.82	96.63	95.73	96.14	95.84	95.54		
97.00								

1 Sample 7-412 Chloritoid
 2 Another twinned grain
 3 Another grain
 4 Another

5 Again
 6 Twinned grain
 7 Average
 8 Average plus sigma

9

SiO2 25.25
 TiO2 .02
 Al2O3 41.90
 Cr2O3 -.00
 FeO 24.20
 MnO .63
 MgO 2.11
 CaO 0.00
 Na2O -.01
 K2O -.00
 SUM 94.09

9 Average minus sigma

(cont. Table 7)

Chloritoid Analyses

	1	2	3	4	5	6	7	8
SiO2	25.28 25.04	25.16	24.98	25.09	25.35	25.17	25.30	
TiO2	.04 .07	.03	.02	.07	.07	.05		
A2O3	38.58 38.51	39.15	38.79	39.23	38.39	38.83	39.15	
C2O3	0.00 .02	0.00	.03	0.00	0.00	.01		
FeO	25.64 25.40	25.28	25.98	26.28	25.56	25.75	26.10	
MnO	.83 .94	1.00	.90	.83	.78	.87		
MgO	2.09 2.03	1.91	1.74	1.91	1.95	1.92		
CaO	.03 .02	0.00	0.00	0.00	.01	.01		
Na2O	0.00 0.00	0.00	0.00	0.00	0.00	0.00		
K2O	0.00 0.00	0.00	0.00	0.00	0.00	0.00		
SUM	92.49 91.56	92.53	92.44	93.41	92.11	92.60	93.63	

1 Sample 7-512

2

3

4

5

6 Average

7 Average plus sigma

8 Average minus sigma

	1	2	3	4	5	6	7	8
SiO2	24.86 24.85	25.88	24.99	25.00	25.39	25.22	25.60	
TiO2	.04 .06	.06	.04	.04	0.00	.04		
A2O3	40.99 41.29	42.37	41.36	42.84	42.27	41.93	42.56	
C2O3	0.00 0.00	0.00	0.00	0.00	0.00	0.00		
FeO	24.38 24.09	23.95	24.64	24.20	24.45	24.32	24.56	
MnO	1.09 1.13	1.11	1.13	1.14	1.11	1.12		
MgO	2.50 3.05	2.95	3.11	2.90	2.78	2.85		
CaO	.02 .02	0.00	0.00	.02	0.00	.01		

NA20	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00					
K20	0.00	0.00	0.00	.02	0.00	.00
.01	-.00					
SUM	93.88	96.32	95.27	95.96	96.00	95.49
	93.98					96.99

1	Sample 7-513 Chloritoid	5
2		6 Average
3		7 Average plus sigma
4		8 Average minus sigma

Table 8: Major Minor and Trace Elements of the Lucy Metavolcanic Footwall Rocks (LeSeelleur, 1980).

Sample	L001	L002	L003b	L003a	L004a	L004b	L005	L006	L007
L010a	L010b	L011a	L011b	L012a	L012b				
Si02b	50.77	36.26	35.60	49.40	31.24	45.89	45.70	26.85	45.33
	36.17	56.36	14.94	36.31	50.69	50.95			
Ti02a	0.30	0.33		0.20	0.43	0.18		0.32	
	0.28	0.17	0.24	0.16	0.53	0.13		0.40	
	0.46	0.67							
Al203b	15.25	12.67		10.55	16.30	9.57		14.40	14.99
	7.52	14.21		6.41	15.43	4.57		11.55	12.35
	14.06								
Fe203b	9.52	20.71		21.56	8.46	24.38		10.17	13.61
	27.90	15.77		20.56	7.73	44.38		20.86	16.83
	13.07								
Mn0a	0.29	0.79		0.78	0.33	1.02		0.44	0.45
	1.20	0.46	0.98	0.30	1.94	0.84		0.76	0.60
Mg0a	1.96	2.38		3.12	1.82	3.06		2.24	2.42
	3.31	2.53	3.32	1.36	3.76	2.69		2.08	1.51
Ca0b	6.65	5.73		8.55	7.15	8.13		8.45	6.98
	8.42	5.93	9.91	4.83	1.72	6.24		1.82	4.64
K20b	0.34	0.658	0.22	0.49	0.23	0.26		0.29	
	0.27	0.24	0.03	0.39	0.00	0.24		0.43	0.37
Na20b		4.15	3.00	1.90	4.20	2.00		2.69	
	2.43	1.70	2.90	1.45	4.10	0.65		2.70	
	2.75	2.89							
P205b		0.21	0.23	0.02	0.09	0.01		0.06	
	0.07	0.02	0.10	0.01	0.11	0.09		0.03	
	0.06	0.06							
L.O.I.c	11.52	17.20	18.66	12.44	20.70	14.29	13.88	23.93	12.98
	22.36	10.10	28.15	17.98	13.02	12.41			
Total	100.96	99.96	101.16	101.11	100.52	99.21	101.2	101.29	100.69
	101.36	101.24	100.33	99.88	101.25	101.33			
S %a	-	0.95	-	-	0.20	-	-	-	-
	-	0.95	-	-					
C02d	9.96	17.04		17.81	10.98	20.51		13.47	11.57
	25.56	10.31		22.75	8.38	28.93		18.12	11.64
	-								
Fe0e	7.53	16.25		17.41	6.79	19.77		8.67	11.12
	22.87	12.78		17.57	6.17	37.42		16.44	13.80
	11.37								
Aga2	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
Bea	0.7	0.8	0.5	0.8	0.5	0.8	0.8	0.5	0.8
	1.6	1.1							
Va	137	124		106	146	94	136	137	80
	160	48	123	105	139				146
Cral	126	64	54	127	44	115	117	14	105
	58	33	68					20	125
Nia	84	50	77	47	64	57	71	51	80
	69	57						49	50
								52	68

Cua	2.7	26	8.5	2.3	65	10	25	63	47	21	36	-	92
3.5	63												
Coa	37	45	45	35	54	24	40	49	39	44	30	50	59
46	39												
Zna	66	59	94	38	66	42	73	63	84	85	24	84	48
57	35												
Moa4	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-												
Pba2	5	20	-	5	-	-	5	-	-	-	5	-	5
-	10												
Tha	17	6	6	18	13	11	20	14	14	13	14	15	6
6	11												
Rbb	27	24	14	26	17	18	19	13	17	15	25	9	16
25	18												
Srb	178		125	92	227	94	208	169	70		149	92	229
30	125		156	193									
Yb	19		196	9	15	9	20	15	13	18	12	27	10
15	24	13											
Zrb	92	76	50	98	60	85	90	52	88	42	94	45	69
86	96												
Nbb	20		221	7	15	1	19	7	7	12	9	25	8
7	16	16											
Cda3	-	-	-	-	-	8	-	-	-	-	-	-	-
7	-												
Bab	181		234	138	223	172	153	178		142	156		
87	189	87	185	109	236								
S.G.f		2.87	3.18		3.10		2.86		3.10		2.89		
2.92	3.19		3.31		3.11		2.86		2.88		3.13		
3.01	3.35												
Al/Tib	15.5		15.4	15.3	15.6	15.6	15.6	15.5	15.4	15.5	15.6	15.4	23.9
15.7	19.3	16.3											
Al/Yb4319		342	6254	5751	5707	3925	5379		3062	4210			
2841	3032	2491	4074	2772	5725								
Al/Zrb636		762	703	634	713	654	714		612	743			
509	611	508	728	640	636								
Ti/Zrb	40.9		49.5	46.1	40.7	45.7	42.0	46.2	39.8	47.8	32.7	30.8	21.2
46.3	33.2	39.0											
Al/Vb	589		542	527	595	539	560	579	493	515			
459	510		504	499	622	538							
Fe2792?/ Fe	.89		.87	.90	.91	.90	.95	.91	.91				
.90	.95		.89	.94	.88	.91	.97						

Table 8: Arithmetic means and standard deviations of chemical analyses from the footwall volcanics.

	%		ppm	
S102	40.83	(10.97)	Ag	-
Ti02	0.32	(0.15)	Be	8.76 (0.32)
Al203	11.99	(3.59)	V	117 (32)
Fe203	18.37	(9.45)	Cr	71 (45)
MnO	0.75	(0.43)	Co	39 (10)
MgO	2.39	(0.71)	Ni	62 (12)
CaO	6.34	(2.36)	Cu	31 (29)
K2O	0.30	(0.17)	Zn	61 (21)
Na2O	2.63	(1.01)	Mo	-
P2O5	0.08	(0.07)	Pb	6 (4)
L.O.I.	10.64	(5.25)	Th	12 (5)
Total	100.77	(0.66)	Rb	19 (5)
	Sr	143 (60)		
S	0.14	(0.33)	Y	28 (47)
CO2	15.93	(0.25)	Zn	75 (20)
FeO	15.06	(7.92)	Nb	26 (54)
Fe2792?/ Fe	0.91	(0.03)	Cd	1 (2.6)
	Ba	165 (48)		
Al/Ti	16.37	(2.3)		
Al/Y	3992	(1612)		
Al/Zr	654	(76)		
Ti/Zr	40.1	(7.86)		
Al/V	538	(44)		

Number of
determinations 15

- b.) Elements analyzed by X.R.F.
- a.) Elements analyzed by Plasma Emission Spectrophotometry.
- c.) LOI = weight percent loss on ignition at 1100°C.
- d.) CO2% = determined on chittick apparatus.
- e.) Fe2792? as FeO % determined by titration with A.M.V.
- f.) S.G. = specific gravity (+ 2%).
- g.) Sensitivity for trace elements.
 - 1 = 0.8 ppm
 - 2 = 5 ppm
 - 3 = 7 ppm
 - 4 = 30 ppm

Table 9: Calculation of Water-Rock Ratios Based on Solubilities, (LeSeelleur, 1980).

Element (footwall rock)	Solubility ^b	+ Element ^a	Water: Rock
Fe	2500	50000	2000:1
Al	15	6700	4500:1
Si	500	74000	14800:1
CO ₂	29200	150000	514:1
Ca	209	13000	6200:1
Sr	2000	100	5:1
Zn	600	20	3:1
Pb	85	20	23:1
Mn	2000	4500	23:1
Cu	6	20	300:1
Ni	2	50	2500
Ag	003	.05	1600:1
Na	129	8850	6900:1
Mg		78	960
			1230:1

a) Element enrichment or depletion is based on mass balance of sample L001 in ppm

b) Solubilities based on actualistic brine systems (Barnes, 1967, Nueller, 1977) at 200-300°C in ppm. (See LeSeelleur, 1980, for references).

Table 10: Abundances of Major, Minor and Trace Elements for the Helen
Footwall Volcanic
Rocks (from MacMillan 1981, p.24).

	74 234B	175 237B	176	177	219A	221	224	234A
SiO ₂ a	45.94 71.76	71.51 68.38	64.16 65.33	70.87 65.49	68.83	73.28	60.29	
TiO ₂ a	0.59 0.49	.53 0.52	0.39 0.42	.65 0.54	0.45	0.43		
Al ₂ O ₃ a	18.02 15.59	17.34 15.89	12.56 13.45	16.33 16.81	15.16	14.55	14.85	
Fe ₂ O ₃ a	13.17 7.82	4.85 3.47	10.83 14.38	7.17 7.53	6.63	5.49	21.04	
MnO _b	0.41 0.30	.04 0.1	.47 0.25	0.06 0.08	1.35	.04		
MgO _a	1.48 1.36	0.30 .29	2.82 1.20	0.48 1.29	1.35	0.88		
CaO _a	7.15 0.00	0.00 1.66	2.68 0.14	0.00 .68	0.00	0.00		
K ₂ O _a	0.98 0.00	2.54 1.61	0.00 0.82	0.93 1.35	2.98	2.69		
Na ₂ O _a	1.16 0.00	6.22 4.62	0.00 0.60	0.82 2.9	0.64	.49		
P ₂ O ₅ a	0.02 0.01	0.03 0.01	0.03 0.00	0.03 0.01	0.01	0.04		
LOI _c	11.67 2.27	2.09 5.1	6.11 3.15	2.24 2.95	3.12	2.27		
Total	101.47 100.64	100.03 100.5	100.06 99.89	100.3 99.99	99.54	100.39	100.61	
Sa	0.01 0.01	0.02 0.02	0.02 0.02	0.01 0.02	0.03	0.02		
CO ₂	-	-	-	-	-	-	-	
Au	-	-	-	-	-	-	-	
Ag _b	<5 <5	<5 <5	<5 <5	<5 <5	<5	<5	<5	
Li	-	-	-	-	-	-	-	
Beb	0.8 <0.1	0.6	1.0 0.8	0.7 0.8	0.7 0.7	0.7	0.7	
B	-	-	-	-	-	-	-	
As	-	-	-	-	-	-	-	
Sb	-	-	-	-	-	-	-	
Scd	15 7	12 1	16 11	15 14	11	9	17	

Vb	114	96.5	48	108	99.6	6.22	114			
62.4		75.1	78	75.1						
Crb	52.4		10.7	9.6	54	79.3		75.1		
70.8		63.6	65.2	48	73					
Nib	45.0		13	17	53	22		29		
70		16	16	43	29					
Cub	<0.8		1.6	3.2	7.5	14.9		2.6		
10.1		<0.8	23	24.4	<0.8					
Cob	47.0		53	40	53	22		21		
63		40	27	34	31					
Znb	112	32	95	63	59		54	115		
52		36	124	36						
W	-	-	-	-	-	-	-	-	-	-
Pbb	5	5	<5	5	10		10		<5	
	<5	10	<5	10						
Thb	15	11	18	11	10		12		13	
	11	10	13	10						
Rba	39	100	11	40	65	66		8		
25		85	32	64						
Sra	205	104	10	123	89	135	2	166		
82	105	168								
Ya	17	22	27	26	26		18	44		
	18	18	30	16						
Zra	119	148	180	201	170	119	189	129	158	149
Nba	5	11	13	12	7		8		6	
	7	9	6	7						
Mob	<33	<33	<33	<33	<33	<33	<33	<33	<33	<33
Cdb	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
	<7	<7	<7	<7	<7					
Baa	370	656	15	364	423	309	16	155	518	
278	454									
Ti/Zr	29.7		21.5	13.1	19.3		16		21.8	
15.7		23.6	19.6	17.1	22.2					
Al/Zr	801	616.3	366	426.3	467.2	643.9	412.7	635.5		
	528.3	474.9	605.5							
Al/Ti	27	28.7	27.8	22	29.3	29.5	26.3			
	26.8	26.9	27.7	27.2						
Al/	63573	7646	4154	5761	7293	8555	4622	11786	84089	6470
Sc										6354

a Elements analyzed by X.R.F.

b Elements analyzed by I.P.C.

c L.O.I. weight loss on ignition at 1100cC

d Elements analyzed by N.A.

Table 11: Iron Ore Production and Reserves, Wawa, Ontario.

Reference	Tons Produced	Ore	Date	Reserves
Helen Iron Range				
Old Helen	2,823,364	hematite	1900-1918	- Colli
ns and Quirke, 1926				
	51,930	pyrite	1900-1918	- Colli
ns and Quirke, 1926				
McLeod	79,491,926	siderite	1939-1984	58,246,000 MDIR
Files (Toronto)		(1984)	Annual reports of Algoma Steel	
Corporation				
	Limited			
Lucy Iron Range				
Lucy Pit	1,107,773	Siderite	1967-1970	4,984,000 MDIR
Eleanor Iron Range				
Sir James Pit	7,790,632	siderite	1958-1967	100,000,000 MDIR
files				
Ruth Iron Range				
	-	siderite	-	30,900,000 MDIR
files				

Note:

Resources at the Eleanor, Lucy and Ruth Iron Ranges are not presently economically recoverable.

Table 12: Tabulated Surface Diamond Drilling for the Eleanor Iron Range

Metres	Company	Hole Series	Number of Date		Footage
			Holes		
	Algoma Ore Properties Limited	XR	4	1948	362 110.3
266.7	"	NX	4	1948	875
5,656.6	"	1-38	38	1948-50	18,555
.8	James Richardson Jr. and Sons Limited		7	1948	5,826 1,775
	Algoma Ore Properties Limited	39-93	55	1956-1958	15,741 4,797.9
	"	94-1201	26	1960-1961	5,430 1,655.1
	"	121-1692	49	1965-1966	11,870 3,618.0
Total	183	58,659	17,879.4		

1 Hole 93 not drilled

2 Hole 130, log incomplete, not included in data summary.

Table 13: Tabulated Surface Diamond Drilling by Algoma Steel Corporation Limited on the Helen Iron Range

Hole Series	No. of Holes	Date	Footage	Meters
100-118	19	1916	18,842.5	5,743.2
501-511	11	1937	2,849	868.4
601-645	45	1940-41	20,850.5	6,355.2
702-778	77	1942-43	23,720	7,229.9
1551-1560	10	1943-44	411	125.3
801-810	10	1944	5,106	1,556.3
901-914	14	1945-46	14,754	4,497.0
1000-1006	7	1946	1,050.5	320.2
1100-1143	44	1947-49	5,446	1,659.9
1145-1199	55	1950-51	22,486.5	6,853.9
1200-1294	100	1951-54	79,194.5	24,138.5
1295-1319	25	?	4,758.5	1,450.4
1320-1336	17	1966-67	15,230	4,642.1
Total for all years			214,699 ft.	65,440.3 m

Table 14: Tabulated Assay Data on Siderite Intersections from Deep
Diamond Drilling
on Johnson Iron Range

Hole	Intersection		Fe(%)	SiO2(%)	Assay		Mn(%)	<OI(%) ¹
					S(%)			
27	971.5-1034.0	33.82	6.55	1.25	2.11	27.52		
28	983.0-1000.02	33.63	9.01	5.05	1.81	22.65		
	1023.5-1046.5	33.25	8.12	2.58	1.95	25.70		
29	861.5-872.0	34.75	4.94	2.49	2.16	25.38		

1 LOI, Loss on ignition

2 Interval 1000.0 to 1023.5 is a dike.

Table 15: Tabulated Estimates of Open Pit Ore, in Place, for Ruth and Lucy Iron Ranges (Jarvis, 1966, p.1).

Company	Ton of Ore In Place	Composition		
		Fe	SiO ₂	S
Jones and Laughlin Jalore Mining Company Limited 4.92	7,148,000	33.93	8.18	
Sherritt-Gordon Mines Limited 5.28	8,331,000	34.00	8.13	
Algoma Ore Properties 5.76	6,160,000	33.73	8.44	

Table 16: Tabulated Surface Diamond Drilling for Lucy Iron Range

Hole Series	No. of Holes	Date	Footage
Jalore Mining Company Limited	64	1948-1950	35,164
Algoma Ore Properties Limited	44 108	1967-1968	6,198.5 41,362.5

Table 17: Tabulated Assay Results in excess of 0.1 ounces per ton
From
Plan Map of Regnery Mines Limited, (AFRO, Toronto)

Trench	Width(ft)	Assay (Ounces per Ton)
R.R. Cut 23.2		0.11
2 96.9		0.12
3 36.0		0.11
4 28.6		0.09
5 11.9		0.07

Diamond Drill Holes	Interval(ft)	Width	Assay
1	0- 33 33.0	0.15	
2	196.5-204.0	7.5 0.25	
3	27.0- 46.0	19.0 0.11	
	240.0-246.0	6.0 0.205	
	365.0-371.0	6.0 0.105	
5	43.5- 46.0	2.5 0.12	
6	29.0- 49.5	20.5 0.107	
	74.0- 81.5	7.5 0.123	
13	39.5- 44.5	5.0 0.155	

Table 18: Tabulated chip sample Assay Data Resulting From Work
Completed by Canabec Explorations Incorporated (Archibald 1977).
(Values 0.04 ounce per ton or better)

Trench	Length (ft)	Ounces Per Ton
1	40.0 0.04	
2	35.0 0.10	
3	55.0 0.05	
4	75.0 0.04	

Diamond Drill Hole	Interval (ft)	Length (ft)	Ounces Per Ton
1	2.5-11.5	9.0	0.04
5	35.0-45.2	10.2	0.08
7	162.0-165.2	3.2	0.11
	171.0-173.5	2.5	0.07

Table 19: Tabulated Assay Data on Grab Samples from the Mammoth Metals Property (Assays by Geoscience Laboratories, Ontario Geological Survey).

Sample Number	Pb(%)	Zn(%)	Au(oz/ton)	Ag(oz/ton)	Description
Main-Sph		27.1			Coarse sphalerite in milky vein quartz
Main-Gal	53.6				Coarse galena in milky vein quartz
MA1A-Ga		0.02	6.88		Coarse galena and pyrite in vein quartz
MA1B-Ga		0.04	16.56		Coarse galena in vein quartz, trace pyrite
MA1-Asp		0.03	-		Coarse crystalline arsenopyrite (50%) in vein quartz
MA1-B3		0.01	8.63		Coarse sphalerite in vein quartz
MA3B		0.01			Coarse arsenopyrite (50%) in granular vein quartz
MA1-B2		0.01			Milky vein quartz with 5 to 10% galena
MA1-B1		0.02			Vein plus wallrock, coarse galena plus sphalerite in vein.
					Coarse arsenopyrite in wall rock.
MA-4A		Trace			Medium grained quartz diorite wall rock
MA-4B arsenopyrite		0.02			Coarse grained
MA-5B		0.02			Weathered quartz vein
MAM-ARS		Trace			Arsenopyrite in vein quartz
MAM GAL		39.88			Coarse grained galena in vein quartz

Table 20: Assay Values on Grab Samples from the Atnel Number 3
 . Vein. (Assay by Geoscience Laboratory, Ontario Geological
 Survey)

Sample	Au oz/ton	Ag oz/ton	Description
AT-1	0.01 ND		Sugary quartz with minor pyrite, Trace chalcopryrite
AT-2	Trace	ND	Sheared quartz feldspar porphyry with quartz eyes up to 3 mm
AT-3	0.01 ND		Iron stained quartz with trace pyrite
AT-4	Trace	ND	Milky quartz vein 10 cm wide. Trace chalcopryrite
AT-5	Trace	ND	Massive 1.5 m wide milky quartz vein.
AT-6	0.06 ND		Massive 2.1 m wide milky quartz vein vein pinches out in both directions.
AT-7	Trace	ND	Lensoid quartz vein 12.8 cm wide in sheared mafic intrusion.
AT-8			Not assayed Quartz feldspar porphyry
AT-9			Not assayed mafic metavolcanic or sheared mafic intrusion
AT-10	0.16 ND		Irregular quartz vein 0 to 30 cm wide in sheared diorite
AT-11	0.18 ND		Sheared quartz carbonate with 25% pyrite. Sulphide zone 1.0 m wide
AT-12	0.30 ND		Sheared and carbonated diorite with 1 to 2% pyrite

- AT-13 6.46 ND Massive granular pyrite in
 pocket 50 x 25 cm in size.
- J-Q Resources Limited obtained
 their best assay here.
- AT-14 Trace ND Quartz vein 37 cm wide in
 sheared and carbonated diorite.
 Pyrite along edges of vein
- AT-15 Trace ND Quartz vein with ankerite
 in sheared diorite
- AT-16 Trace ND Irregular trending quartz
 vein 60 cm wide in quartz-
 feldspar porphyry
- AT-17 0.01 ND Quartz vein 10 cm wide in
 quartz-feldspar porphyry
- AT-18 0.02 ND Quartz vein 22 cm wide in
 quartz feldspar-porphyry.
 Traces of pyrite and chalcopyrite

ND = none detected

Table 21: Tabulated Assay Data on Grab Samples From the Joseph Bukell Copper Showing (Assays by Geoscience Laboratory, Ontario Geological Survey)

Sample	An oz/ton	Ag	Cu oz/ton	Pb	Description
BU-1					Altered quartz-feldspar porphyry
BU-2	NA	NA	5280 ppm		Quartz veined quartz-feldspar porphyry with 2% chalcopryrite
BU-3					Mafic intrusion, diabase
BU-4	0.01		720 ppm		Silicified quartz-feldspar porphyry with disseminated chalcopryrite
BU-5	Tr	0.52	1280 ppm	5520 ppm	Mostly vein quartz from quartz-feldspar porphyry pyrite, chalcopryrite, galena
BU-6	0.01		2.6%		Sugary vein quartz with 10 to 15% chalcopryrite
BU-7	Tr		660 ppm		Quartz veined chlorite schist with 1% pyrite plus chalcopryrite
BU-8					Massive mafic metavolcanic
BU-9					Reddened quartz-feldspar porphyry with quartz veining and chlorite schist
NA - Not assayed					

Table 22: Tabulated Assay Data from Number 1 Vein, Firespur
Explorations Property Limited (Channel Samples
Reported by Allen (1928)).

Sample No.	Au oz.	Width	Cut
1	0.04 2.5'	0.56	
2	0.12 9'	0.75	
3	0.08 11'	1.41	
4	0.04 7'	0.75	
5	0.16 15'4"	0.28	
6	Trace 12'	0.09	
7	0.08 7'	3.72	
8	0.12 6.5'	0.14	
9	0.04	10.5'	1.18

* This width of sample is given both as 2.5 feet and 21.5 feet by Allen (1928, p. 11)

Table 23: Tabulated Surface Diamond Drilling for the Sunrise Lake
Peridotite, Firespur Explorations Limited

Company	No. of Holes		Date	Footage	Hole
Lakemount Prospecting Syndicate	71	1943	566.3	XR1-10	
Lakemount Prospecting Syndicate and Lakemount Mines Limited	242	1943	9,395	11-35	
N.A. Timmins Limited	293	1943-1944	16,093.5	36-64	
?	114	?	1415.2	XR-A thru K	
?	45	?	2,306	S1-4	
Kelore Mines Limited	356	1952-53	19,499	101-136	
Ventures Limited	31	1953	17,266.3	V201-231	
New Kelore Mines Limited	14	1956	12,460.5	301-316	
Lakemount Mines Limited	5	1960	1,000(?)	9	?
Firespur Explorations Limited	108	1980, 1982	3,385 82,386.8	25,111.5	

- 1 Hole locations unknown, no records for holes 3, 4 and 6
- 2 Hole 15 not drilled
- 3 Uncertain if holes drilled by M.A. Timmins Limited
- 4 No record of who, when, or where these holes were drilled.
Drilling possibly by N.A. Timmins Limited.
- 5 S-series holes drilled by persons unknown from south shore of
Sunrise Lake.
- 6 Holes 105 and 106 not drilled.
- 7 Drilling reported in 1960, Canadian Mines Handbook 1961, p.132,
No records could be located for this drilling.
- 8 Only holes 2, 3, and 4 complete in Sunrise Lake Peridotite.
- 9 Not included in total. Not drilled on peridotite.

Table 24: Tabulated Grade and Tonnage Estimates for the Sunrise Lake Peridotite as Calculated by Various Authors.

Investigator

Reserves

Simard 1952 1,403,600 ton grading 0.56% Cu; 0.58% Ni and 0.05 ounces/ton platinum and palladium. No Au, Ag.
Zone 1950 feet long, to a depth of 400 feet, width 24.3 feet.

McCombe 1952, p 5,6 F Zone - East End

700,000 tons averaging 0.40% Cu, 0.50% Ni
Zone 500 feet long, 41 feet wide, 340 feet deep from 200 to 540 foot level.

F Zone - West End

440,000 tons averaging 0.28% Cu, 0.56% Ni
Zone 650 feet long, 20 feet wide, 340 feet deep from 200 to 540 foot level

Note:

Carrying "F" zone - east to surface would result in 1,123,000 tons and carrying "F" zone - west to surface would result in 702,000 tons

Adding an additional strike of 300 feet to "F" zone - east results in 1,894,000 tons. Adding 500 feet of strike to "F" zone - west results in 1,242,000 tons.

The sum total of the above is 3,136,000 tons over a strike length of 1950 feet to a depth of 540 feet grading 0.32% Cu and 0.51% Ni.

Robinson 1952 Eastern part of zone contains 1,123,000 tons grading 0.40% Cu, and 0.50 % Ni over a length of 500 feet, width of 41 feet to a depth of 540 feet.

Western part of zone contains 702,000 tons grading 0.28% Cu and 0.53% Ni over a length of 650 feet, width of 20 feet to a depth of 540 feet.

Martin, 1953, p.1 Middle (East?) Shoot
547,000 tons grading 0.50% Cu and 0.60% Ni over length of 730 feet, width of 30 feet and depth of 250 feet.

West Shoot

352,000 tons grading 0.29% Cu and 0.60% Copper over a length of 800 feet, width of 20 feet, and depth of 220 feet.

899,000 tons grading 0.41% Cu and 0.60% Ni without dilution.
1,348,000 tons grading 0.27% Cu and 0.40% Ni if diluted with
50% barren rock. 1,348,000 tons grading 0.30% Cu and 0.45% Ni if
diluted with 50% barren rock grading 0.10% Cu and 0.15% Ni.

Johnston 1957, p.2 Estimates 2,000 tons grading 0.40 % cm and
0.60% nickel and 0.02 ounces/ton platinum-
palladium. Ore is present over a strike length of
2,200 feet.

Hodder 1959 Estimates 0.5 million tons grading 0.4% Cu and
(see McGregor 0.7% Ni.
1968)

McGregor 1968 2.5 million tons grading 0.35% Cu and 0.55% Ni
and approximately \$1.00 per ton precious metals.
Strike length 2,600 feet, maximum dip 800 feet,
and variable widths. Open pit ore to a depth
of 535 feet is estimated 1.7 million tons grading
0.37% Cu and 0.55% Ni.

Table 25: Tabulated Assays on Grab Samples From the Murray Algoma Mining Company Limited Gold Occurrence. The Indicated Trenches are Believed to be Trenches 1, 4, and 5.

(All samples from muck piles next to trenches). (Assays by Geoscience Research Laboratory, Ontario Geological Survey)

Sample	Au oz/ton	Ag oz/ton	Description
MA-1	0.18 ND		Vein quartz with coarse silvery pyrite
MA-2	0.06 ND		Wall rock to sample MA-1. Silicified felsic tuff?
MA-3	0.06 ND		Milky quartz vein material with 2 to 3 % pyrite
MA-4	0.01 ND		Silicified felsic volcanics with 3 to 5% pyrite
MA-5	0.48 ND		Milky quartz vein with 1 to 2% pyrite
MA-6	0.01 ND		Silicified felsic metavolcanics with tourmaline and 2% pyrite
MA-7	0.01 ND		Milky vein quartz with tourmaline and up to 2% pyrite
MA-8	Trace	ND	Milky quartz with sericite and trace pyrite
MA-9	0.02 ND		Milky vein quartz with ankerite
MA-10	Trace	ND	Milky vein quartz with minor sericite
MA-11	Trace	ND	Carbonated felsic metavolcanic with tiny actinolite crystals
MA-12	0.06 ND		Barren milky quartz vein

ND = Non detected

Table 26: Tabulated assay data obtained by Murray Algoma Gold Mines Limited (AFRO)

CORE-SAMPLING

CHANNEL-SAMPLING

Hole	Width	Value		Vein	No.	Width	03 Per Iron Trench
1	3'00"	\$0.35	4	1	5'5"	Trace	1
2	2'0"	NIL	4 2	5'5"	0.19	1	
3		NOT ASSAYED		4	3	9'0"	0.38 3
4	2'6"	\$4.55	4	4	6'0"	0.17	5
5	3'6"	BL VEIN-TR		4	5	5'0"	0.05 6
6	5'6"	\$4.55	4	6	4'0"	0.19	6
7	3'6"	\$7.00	M	7	5'0"	1.13	3
8	3'0"	\$0.70	M	8	4'10"		1.62 3
9	5'7"	NIL	M	9	4'0"	0.18	2
10	5'0"	NIL	M	10	5'0"	0.05	2
11	11'0"	NIL	M	11	5'0"	0.09	2
12	3'0"	\$1.05	M	12	10'0"		0.14 2
13	2'0"	\$0.70	M	13	6'0"	0.17	4

N.B: Holes #5 and #6 are missing from accompanying map

Table 27: Tabulated Diamond Drilling for Ruth Iron Range (AFRO)

Company	No. of Holes	Date	Footage
Bethlehem Steel Corporation	8	1930	2,274
Michipicoten Iron Mines Limited	96	1942	46,692
Jalore Mining Company Limited	7	1951	4,239
Algoma Ore Properties Limited	12	1968	1,571
Total			54,776

Table 28: Tabulated Assay Data on Grab Samples from the Soocana-Reed Booth Gold Occurrence. (Assays by Geoscience Laboratory, Ontario Geological Survey)

Company Number	Au oz/ton	Ag oz/ton	Description
SO-1	trace	Trace	Sheared quartz-feldspar porphyry carbonated, trace pyrite (Galena Vein)
SO-2	0.10	0.10	Carbonate vein material from vein 3 feet wide (Galena Vein)
SO-3	0.01	Trace	Schistose mafic metavolcanic from wall rock of carbonate vein (Galena Vein)
SO-4	Trace	Trace	Quartz vein with trace of pyrite (Fissure Vein)
SO-5	Trace	Trace	Sheared carbonated quartz-feldspar porphyry. (Fissure Vein)
SO-6	Trace	0.10	Chlorite schist wall rock with trace pyrite (Shaft Vein)
SO-7	0.73	0.99	Chlorite schist with quartz stringers. Pyrite and galena present (Shaft Vein).
SO-8	0.19	ND	Sugary quartz with 0 to 15% pyrite. Rare galena, trace chalcopyrite. Associated with chlorite schist and pink carbonate
SO-9	0.14	ND	Same as SO-8
S-10	0.05	ND	Granular vein quartz with chlorite schist. Five to 10% pyrite in chlorite schist
S-11	Trace	ND	Milky barren quartz from Fissure Vein. Vein is 41 cm wide
SO-12	0.01	ND	Milky barren quartz from Fissure Vein. Vein is 0.6 m wide
SO-13	Trace	ND	Milky barren quartz from Fissure Vein. Vein is 0.5 m wide
SO-14	0.23	ND	Poorly exposed quartz vein at edge of stripped area. Appears barren. Fissure Vein area
SO-15	Trace	ND	Milky quartz vein that is barren. Vein is 55.9 cm wide. Sample from Fissure Vein
SO-17	0.30	ND	Granular vein quartz with 5 to 10% galena 10 to 15% pyrite, trace chalcopyrite. Sample from Galena Vein.

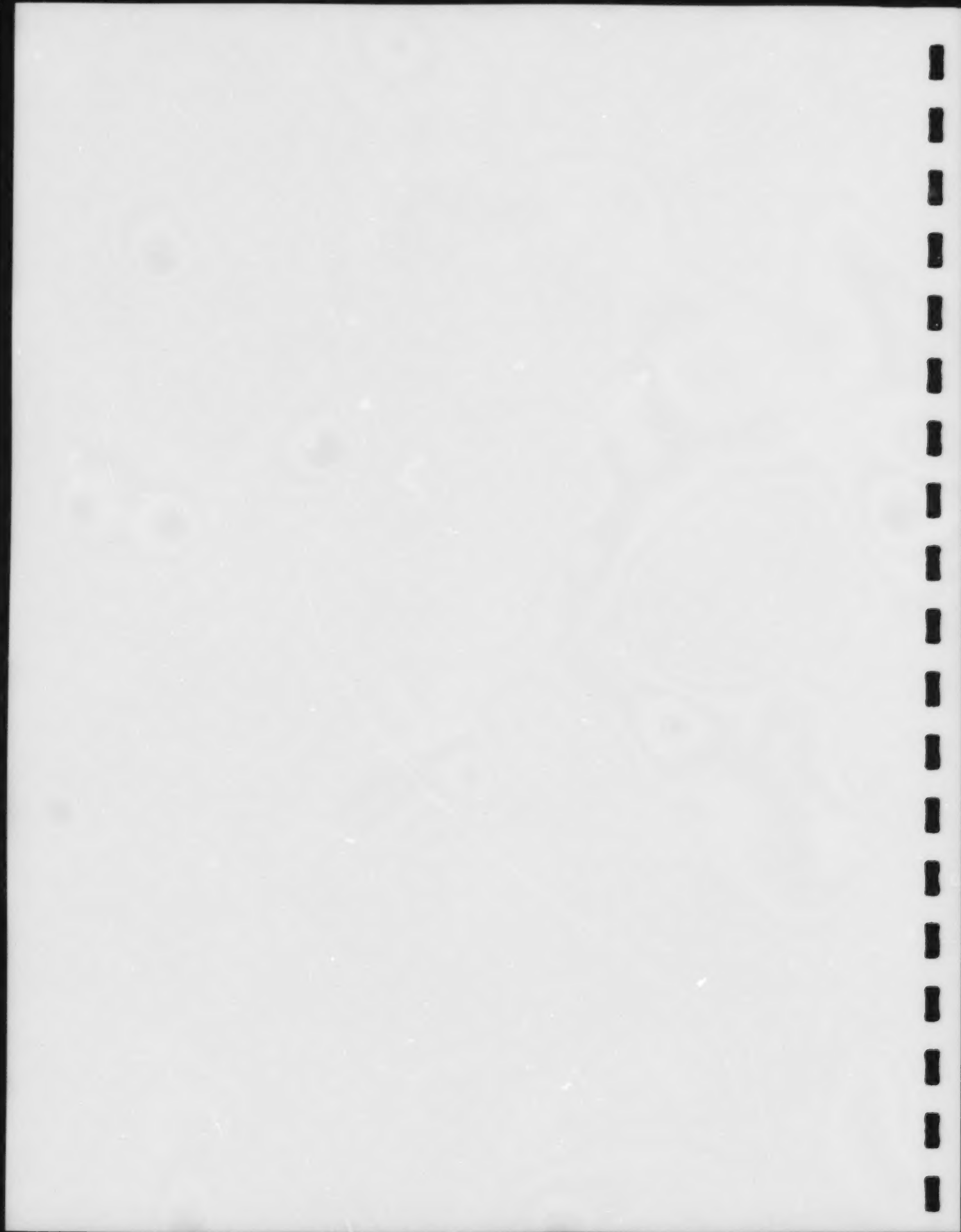


Table 29: Summary Table of Drilling Results, Aldo Palma Molybdenite

Showing, Amax Minerals Exploration Limited (from Yule, 1980)
(AFRO)

Zone	Co-ordinate	Hole #	Depth (feet)	Grade (%)	Recovery (%)
East	3+75W to 5+00W	7, 8, 9, 9a, 10	22.4'	.05	54
	N of Baseline	10a, 11, 12, 13 (16), 17, 17a			
Central	6+00W to 7+50W	5, 6 (14), (14a)	36.75'	.007	48
	N of Baseline	15, (18), 19			
West	8+50 to 10+00W	1, 1a, 1b, 2, 2a, 3, 4	37'	.016	28
	N of Baseline				

Table 30: Tabulated Surface Diamond Drilling for Citadel Mines

<u>Property</u>			
Company	Series Plus No. of Holes	Date	Footage
Sutherland and Company plus Surluga Gold Mines Limited	1-89(89)	1960-1962	35,559.2
Consolidated Mining and Smelting Company of Canada Limited	90-109(20)	1963	7,678
Surluga Gold Mines Limited ₁	110-183(69)2	1963-1965	35,746.3
Surluga Gold Mines Limited	5 (C-series) (Cooper Vein)	1969	1,464
Pango Gold Mines			

1 Log headings are for both Surluga Gold Mines Limited or Pango

Gold Mines Limited.

2 No logs for holes 113 thru 120. Several locations have two or more holes completed with the same number. These are usually designated A, B, etc.

Table 31: GOLD PRODUCTION FROM MINTO MINE BY LEVELS
(compiled by Rupert 1979)

Year	Tonnage by Levels			Recovery Oz. of Gold	Average Grade Oz. Au per ton
	First	Second	Third		
1931	9448			3521	0.373
1932	6229	12537		7907	0.421
1933	2367	8285	13019	6284	0.265
1934	<u>3412</u>	<u>1560</u>	<u>5271</u>	<u>4044</u>	<u>0.325</u>
Total	21456	22382	18290	20756	0.334

Table 32: PRODUCTION STATISTICS, DARWIN OR GRACE MINE
(Compiled by Rupert 1979)

Year	Reported Production		Average Annual Gold Price/Ounce	Ounces of Gold Produced
	Tons Ore	Product		
1902)	6097	\$48,708	\$18.11	est. 2690
1903)			\$18.11)	
1907)			17.42)	
1908)	4260	\$23,325	17.41)	
1909)			15.88)	17.50
1910)			18.92)	est. 1333
1923	Nil	\$ 153.	23.40	est. 6
1925	Nil	\$ 41.	20.50	est. 2
1930	750	28 oz.		28
1935	2103	504 oz.		504
1936	17598	6598 oz.		6598
1937	14720	6131 oz.		6131
1940	Nil	\$ 7,614	\$35.00	218
1943	Nil	\$2,175	\$35.00	62
1944	<u>Nil</u>	481	\$35.00	<u>14</u>
	45528			17586

Table 33: Tabulated Diamond Drill Hole and Assay Data for Dunraine Mines Limited (Assays for sections 0.10 ounces per ton or greater)(AFRO)

<u>Date</u>	<u>No. of Holes</u>	<u>Footage</u>
1980	38 ₁	11,106
1981	20	4,920.7
1982	8	1,347
1983		
Total	66	17,373.7

1 Holes 17 and 36 not drilled

<u>Hole</u>	<u>1980 Interval (feet)</u>	<u>Assay Gold (ounces per ton)</u>
9	261-262.3	0.302-0.199
18	269.5-272.4	1.31
24	306.3-307.0	0.33
30	152.2-154.1	0.12
	1981	
2	177.7-178.2	1.02
	185.0-186.5	0.10
4	245.0-246.5	0.45
8	252.3-254.4	0.461
11	160.7-162.0	0.10
19	78.5-80.0	0.15
	80.0-80.8	0.17
	1982	
2	67.0-71.0	0.158
4	89.0-92.0	0.16
	94.0-98.0	0.275

EXTERNAL GRANITES, AREA 1

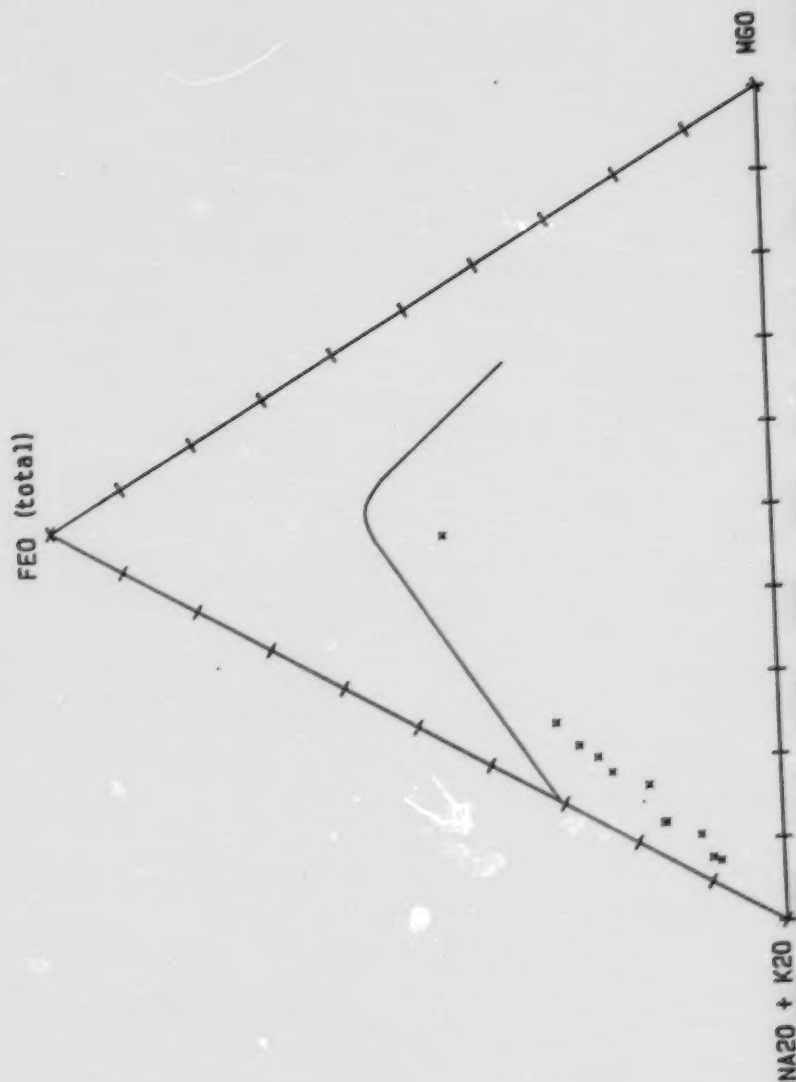


Figure 4 Jensen cation plot of external granitic rocks

EXTERNAL GRANITES, AREA 1

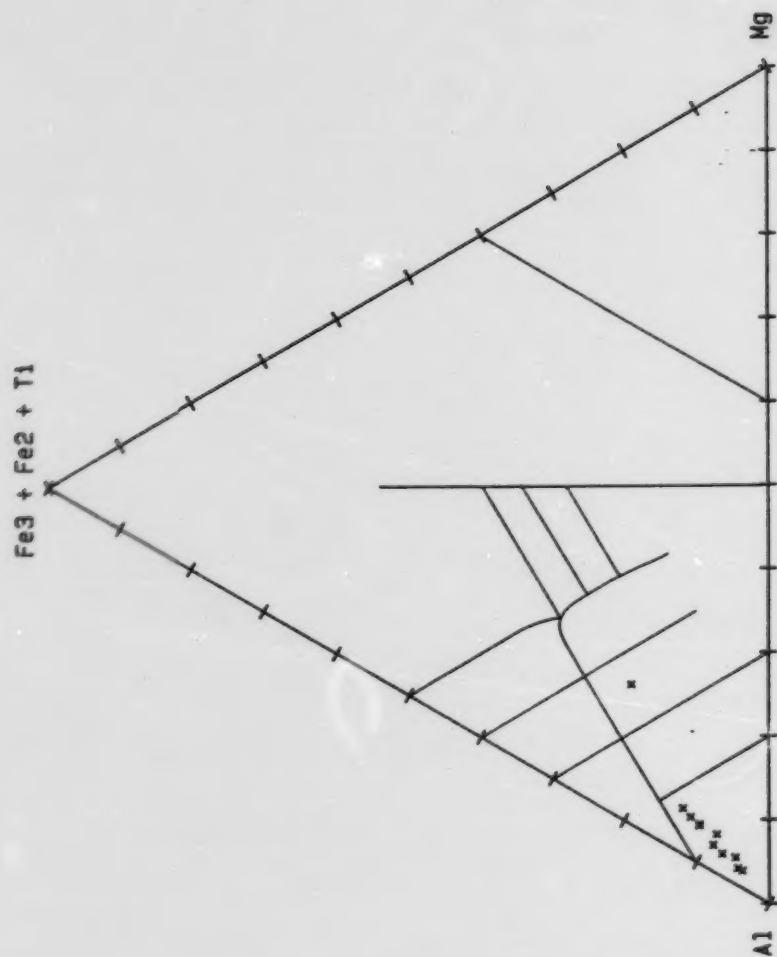


Figure 3 Streckeisen plot of norms for external granitic rocks

QAP EXTERNAL GRANITES, AREA I

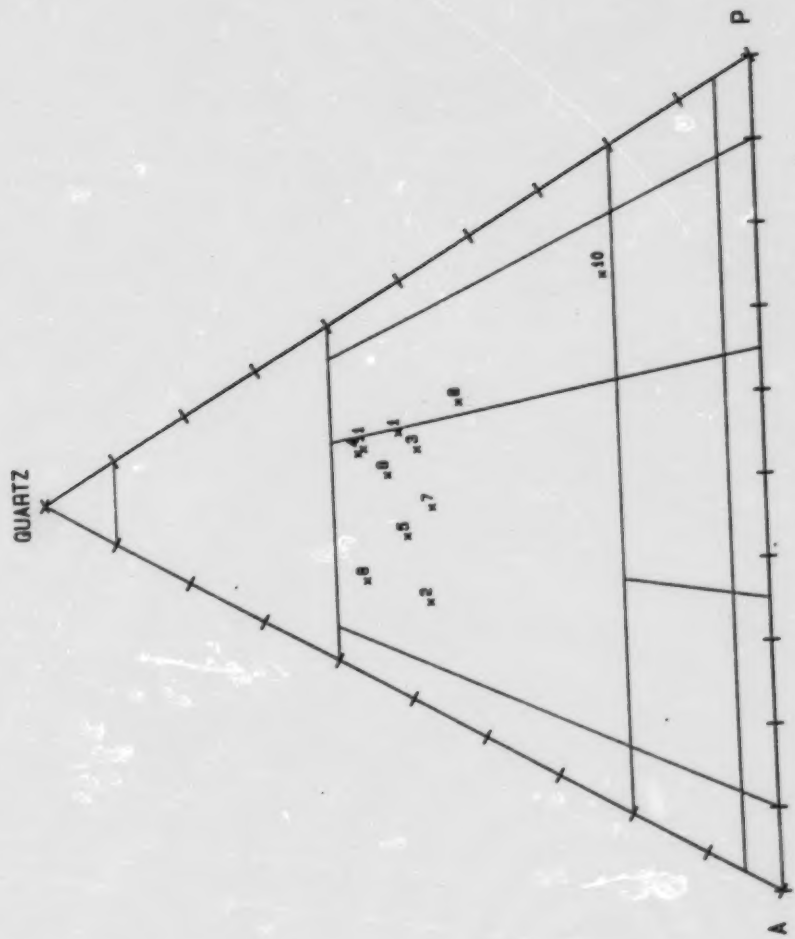


Figure 6

Jensen cation plot of first cycle intermediate to mafic
metavolcanics

MAFIC VOLCANICS: CYCLE 1, AREA 1

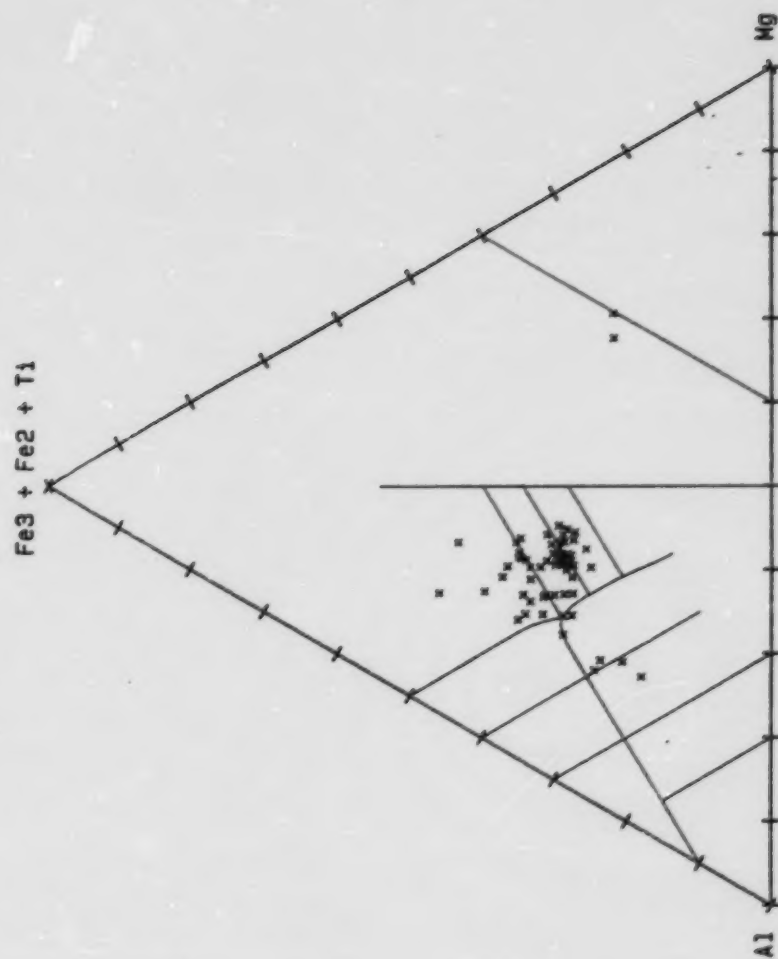


Figure 7 AFM plot of first cycle intermediate to mafic metavolcanics

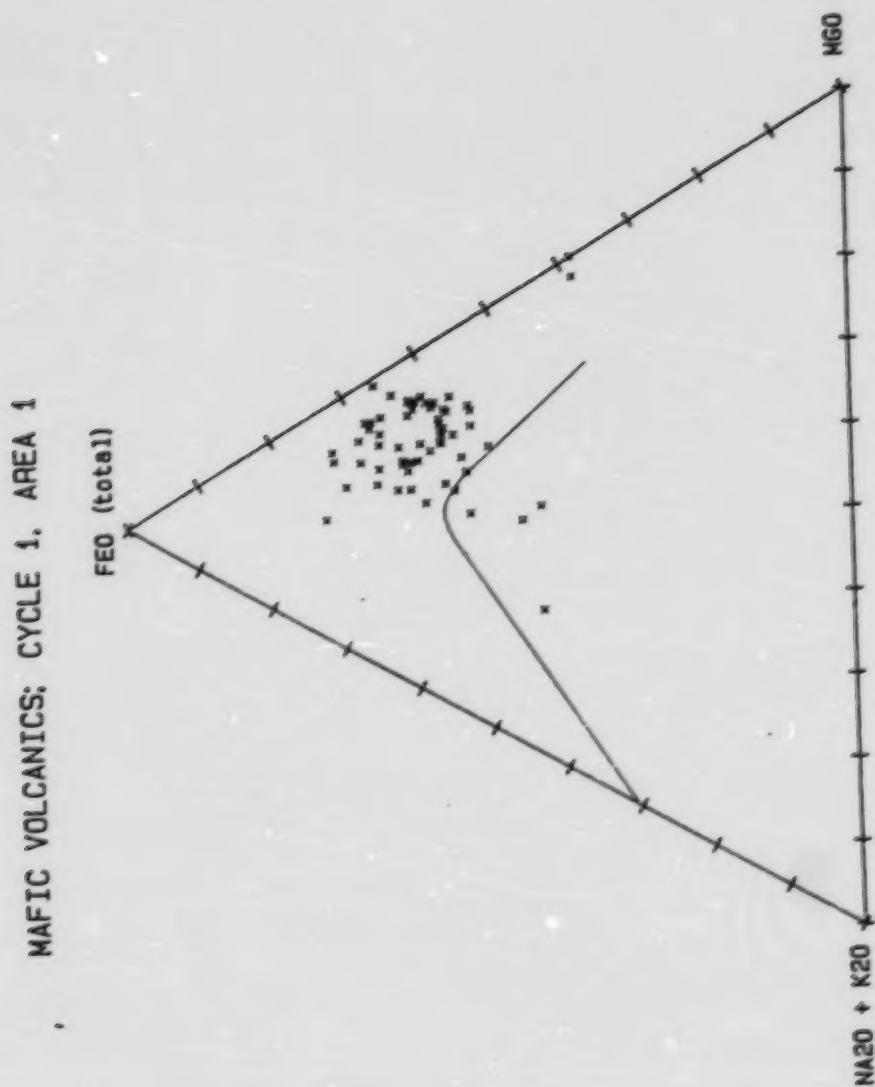


Figure 8 AFM plot of intermediate to mafic metavolcanics of the Lucy Iron Range footwall rocks

INTERMEDIATE TO MAFIC METAVOLCANICS CYCLE I, LUCY

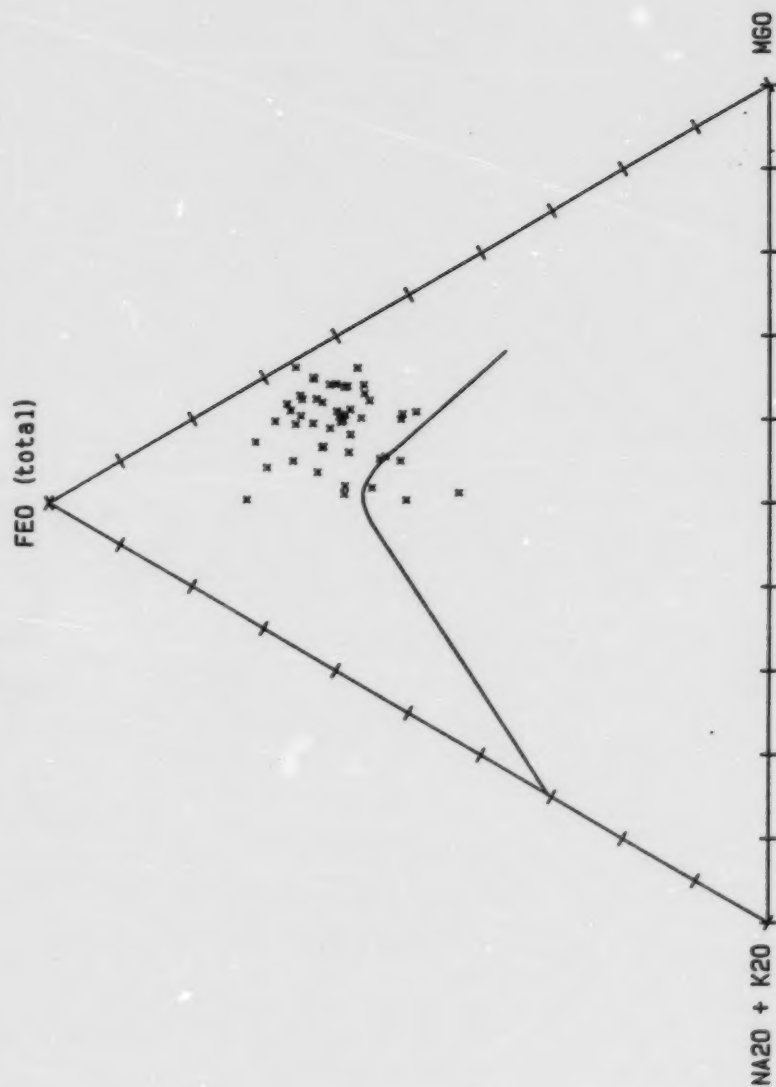


Figure 7 Jensen cation plot of intermediate to mafic metavolcanics of the Lucy Iron Range footwall rocks

INTERMEDIATE TO MAFIC METAVOLCANICS CYCLE I, LUCY



Figure 10 Jensen cation
 plot of first cycle (square) and second cycle (x)
 intermediate to mafic metavolcanics

FIRST AND SECOND CYCLE INTERMEDIATE TO MAFIC METAVOLCANICS

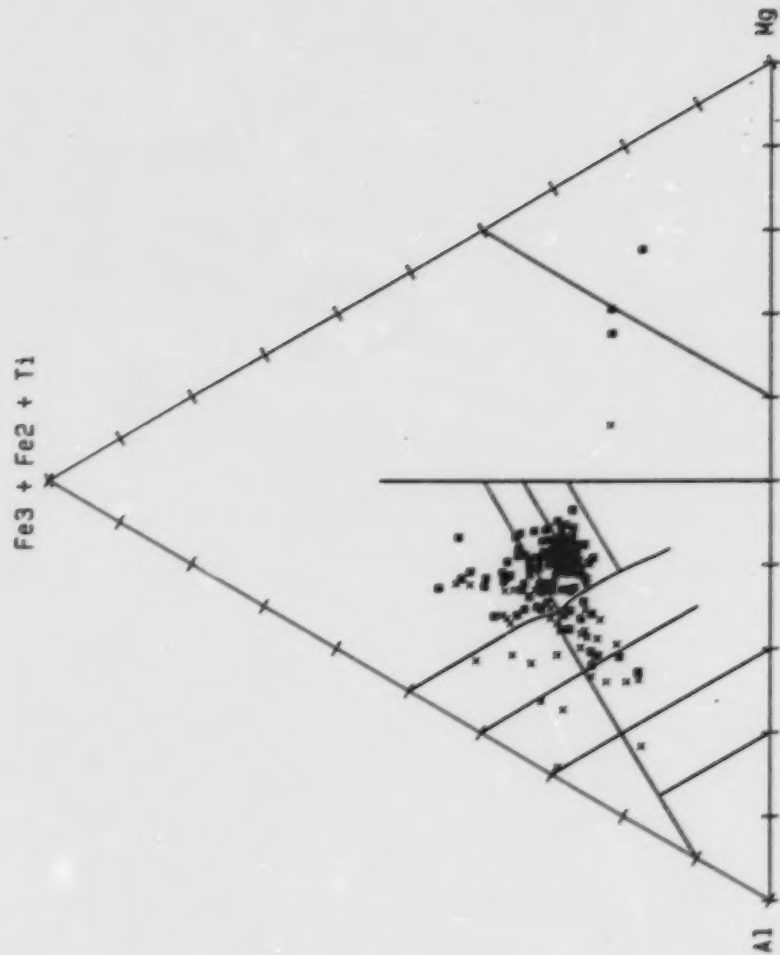


Figure 1) AFM plot of second cycle intermediate to mafic
metavolcanics above Lucy Iron Range

SECOND CYCLE INTERMEDIATE TO MAFIC METAVOLCANICS ABOVE LUCY IRON RANGE

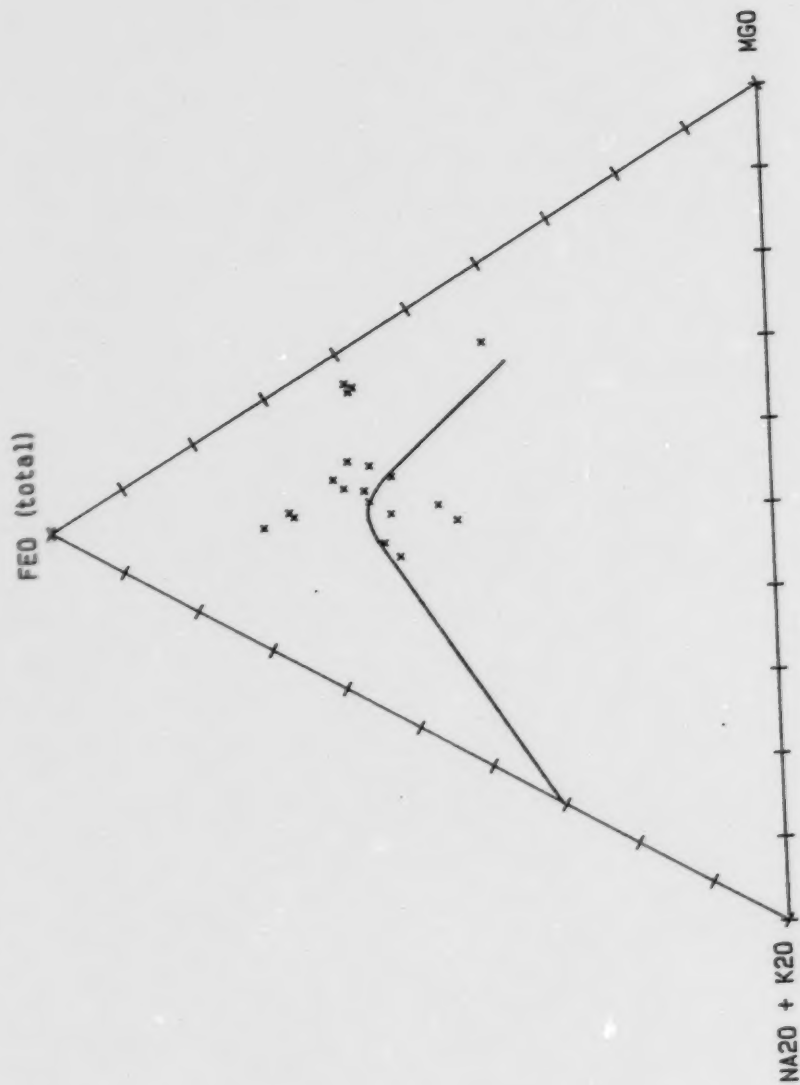
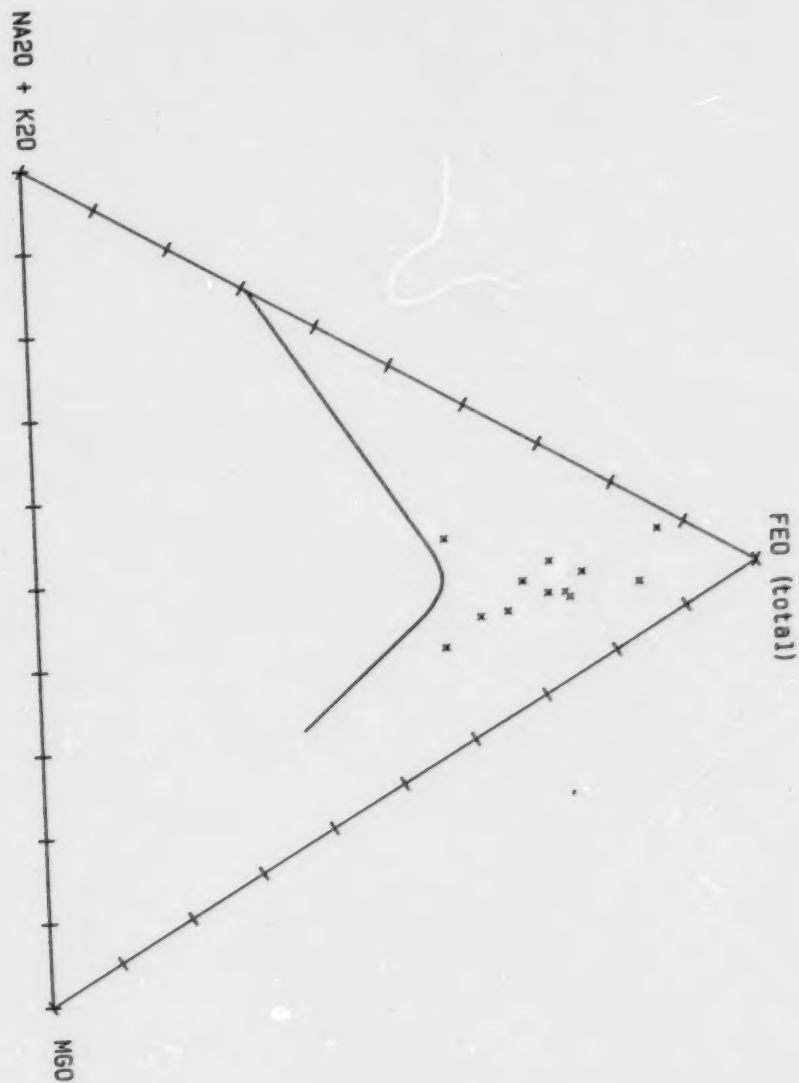
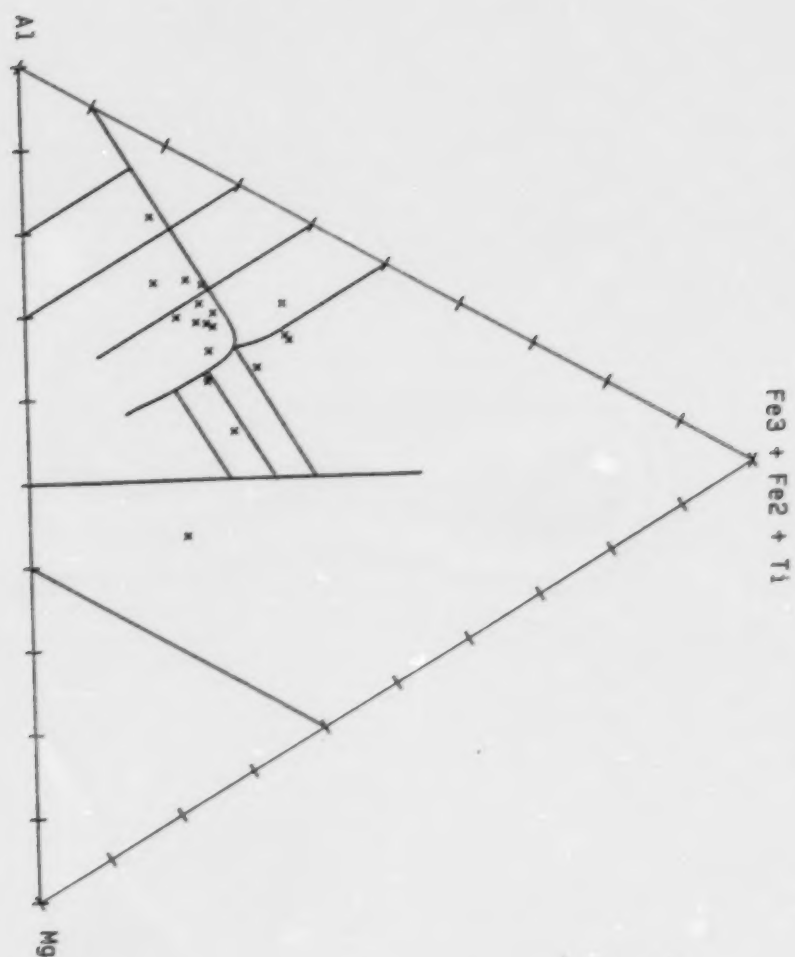


Figure 12. AFM plot of second cycle intermediate to mafic
metavolcanics above Helen Iron Range

SAGE

HELEN SECOND CYCLE





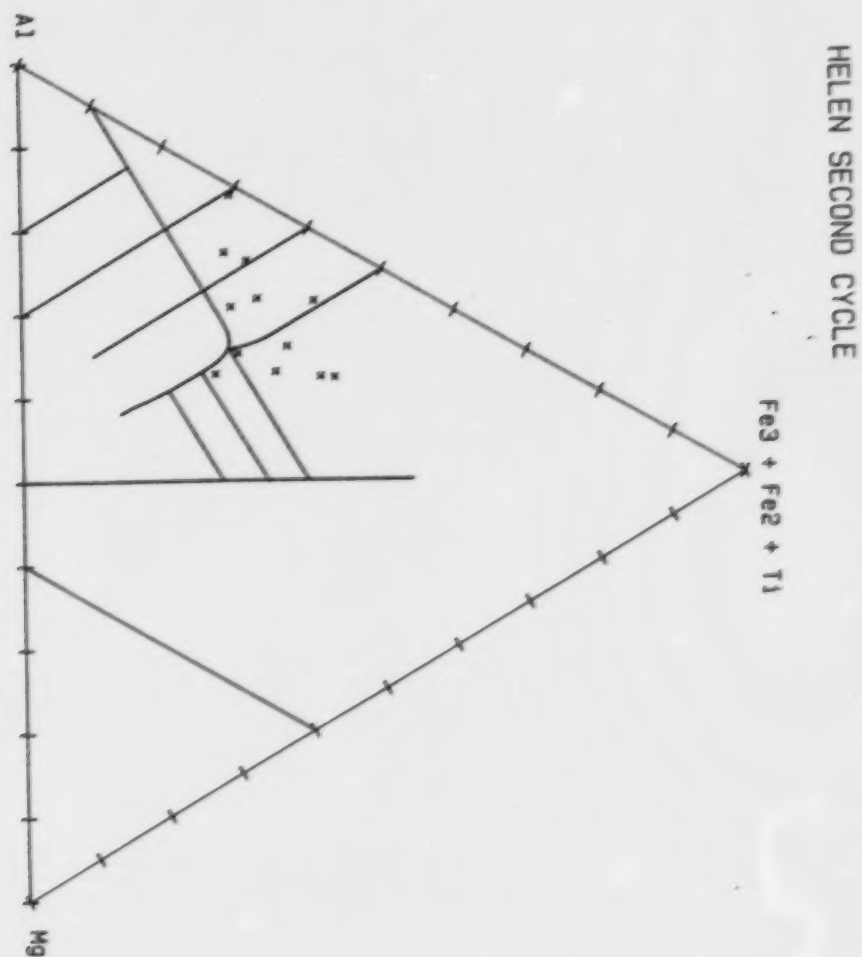
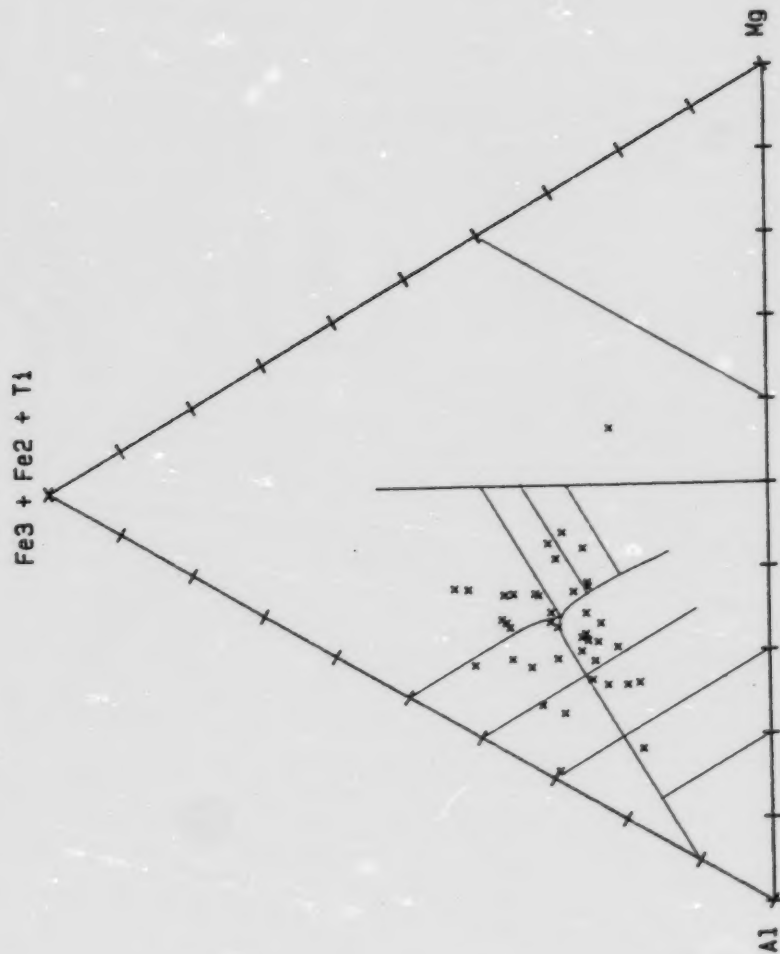
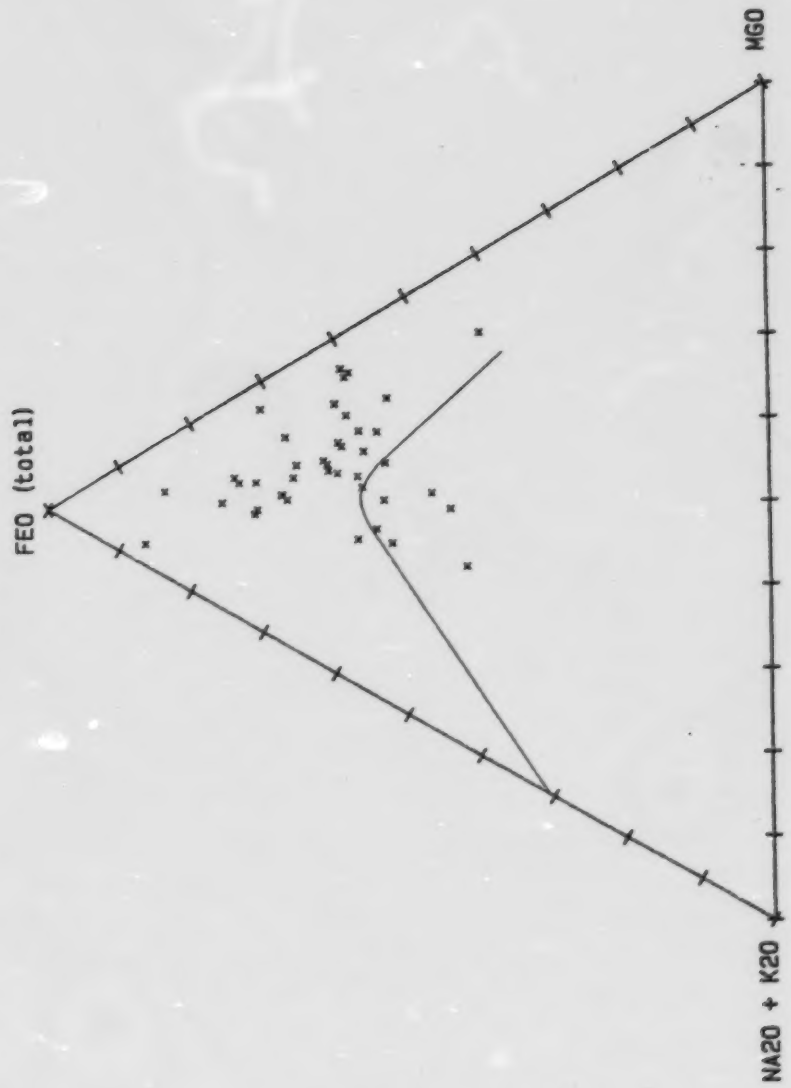


Figure 18 Jensen cation plot of all cycle two intermediate to mafic metavolcanics

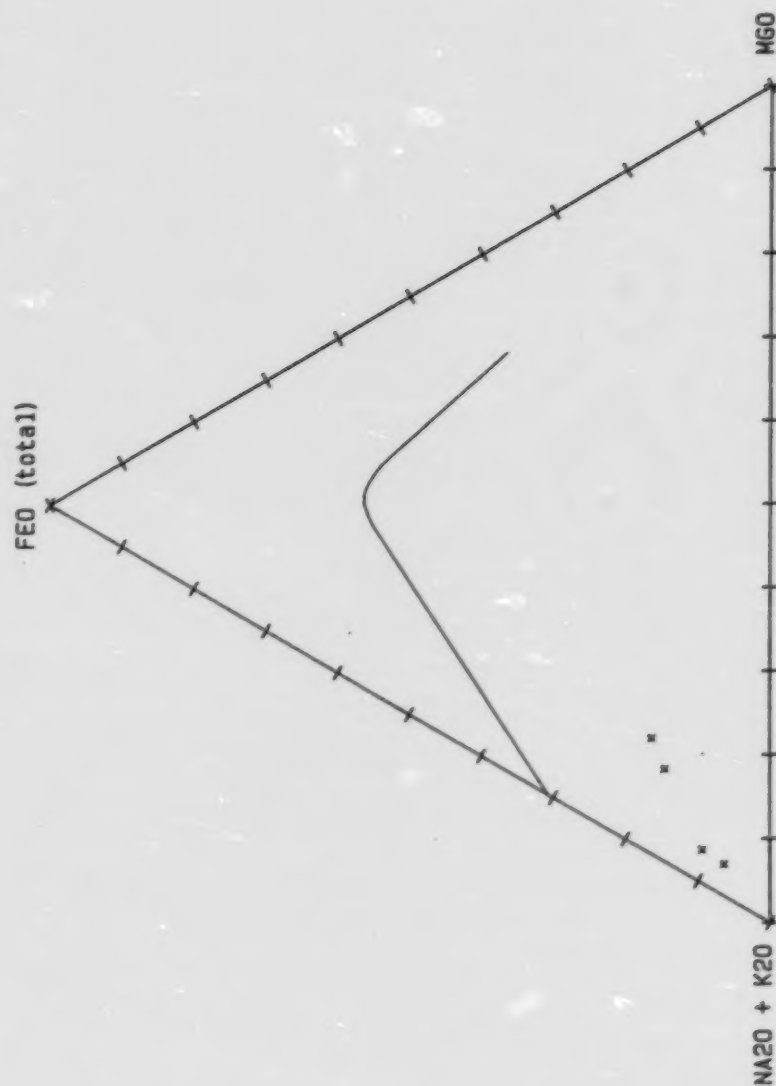
MAFIC VOLCANICS: CYCLE 2, AREA 1



MAFIC VOLCANICS; CYCLE 2, AREA 1



INT-FELSIC VOLCANICS; SUB-CYCLE 1, AREA 1



SAGE

Figure 88 Jensen cation plot of subcycle one intermediate to felsic metavolcanics

INT-FELSIC VOLCANICS; SUB-CYCLE 1, AREA 1

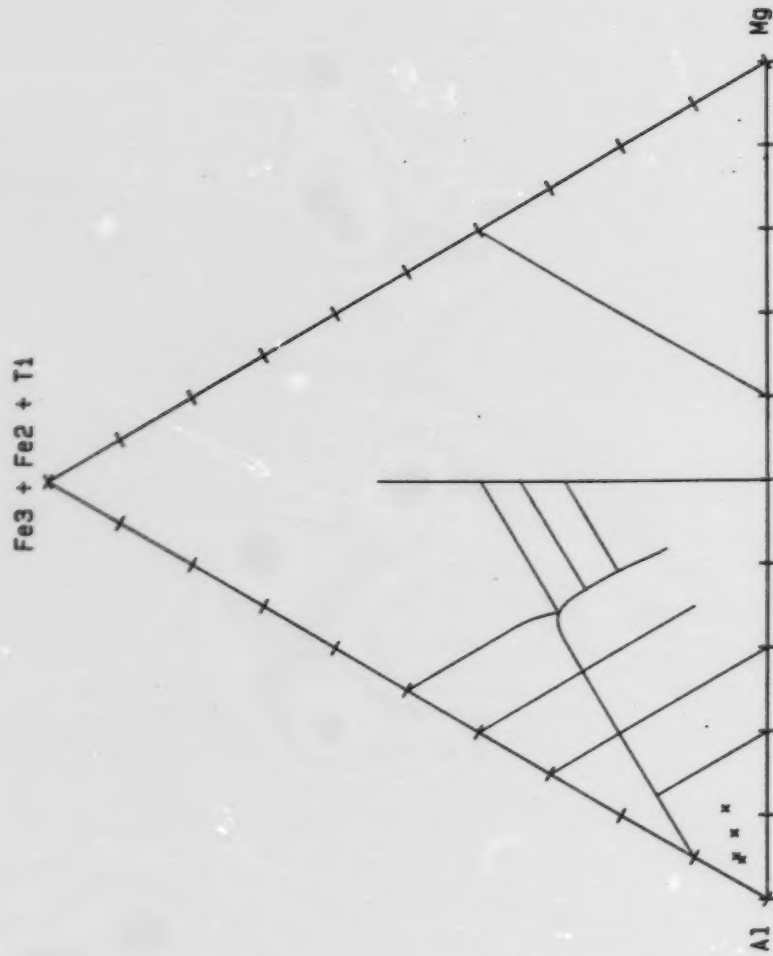


Figure 49

AFM plot of intermediate to felsic metavolcanic rocks in Stanley lake area and below Judith Iron Range

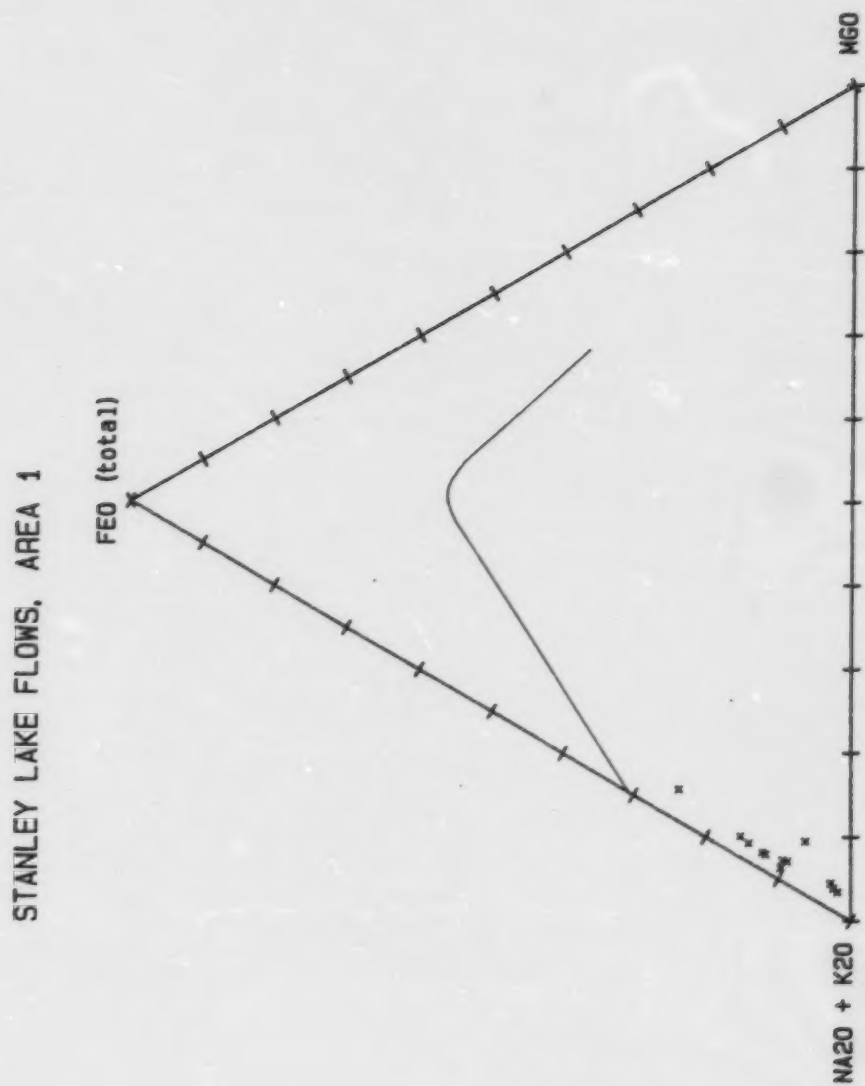


Figure 26 . Jensen cation plot of intermediate to felsic metavolcanic rocks in Stanley lake area and below the Judith Iron Range

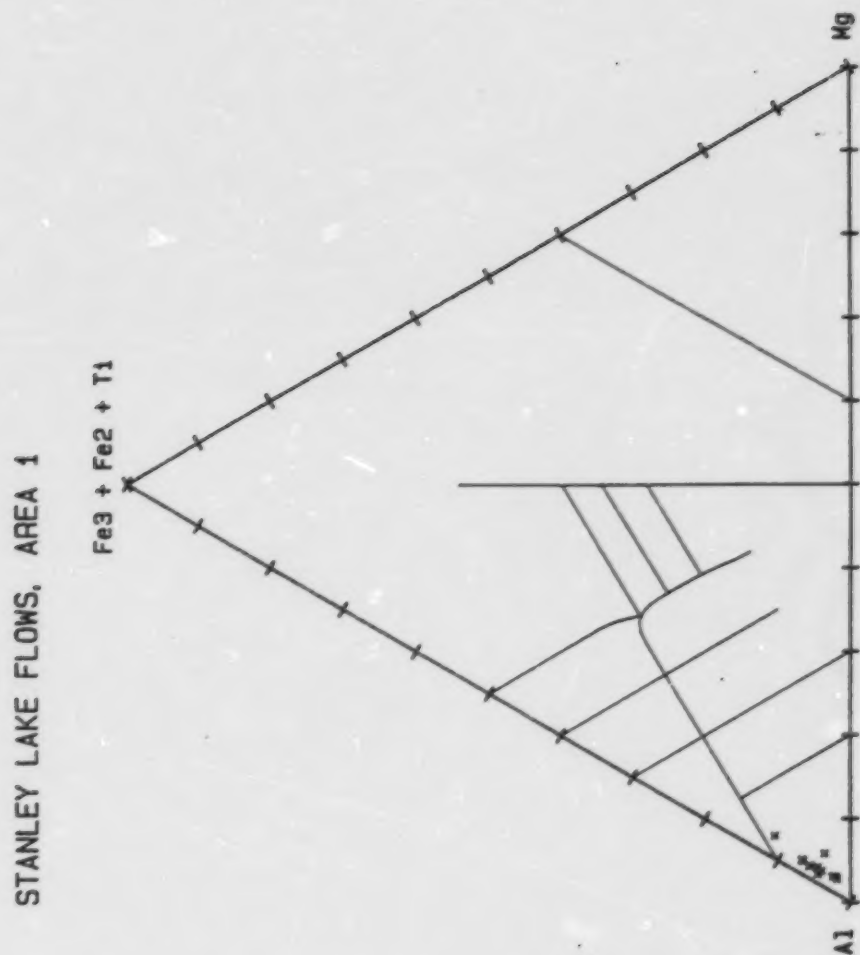
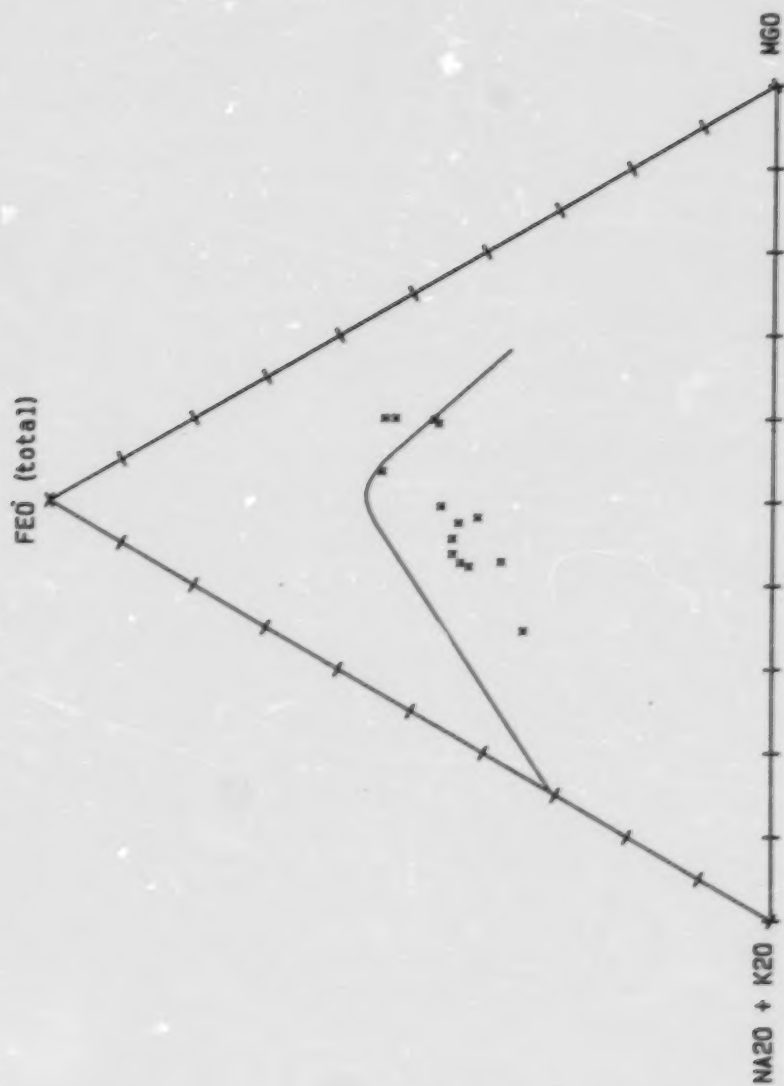


Figure 29 AFM plot of Jubilee feldspar-free tuffs

JUBILEE TUFFS 30, AREA 1



303

SAGE

Figure 22 Jensen cation plot of Jubilee feldspar-free tuffs

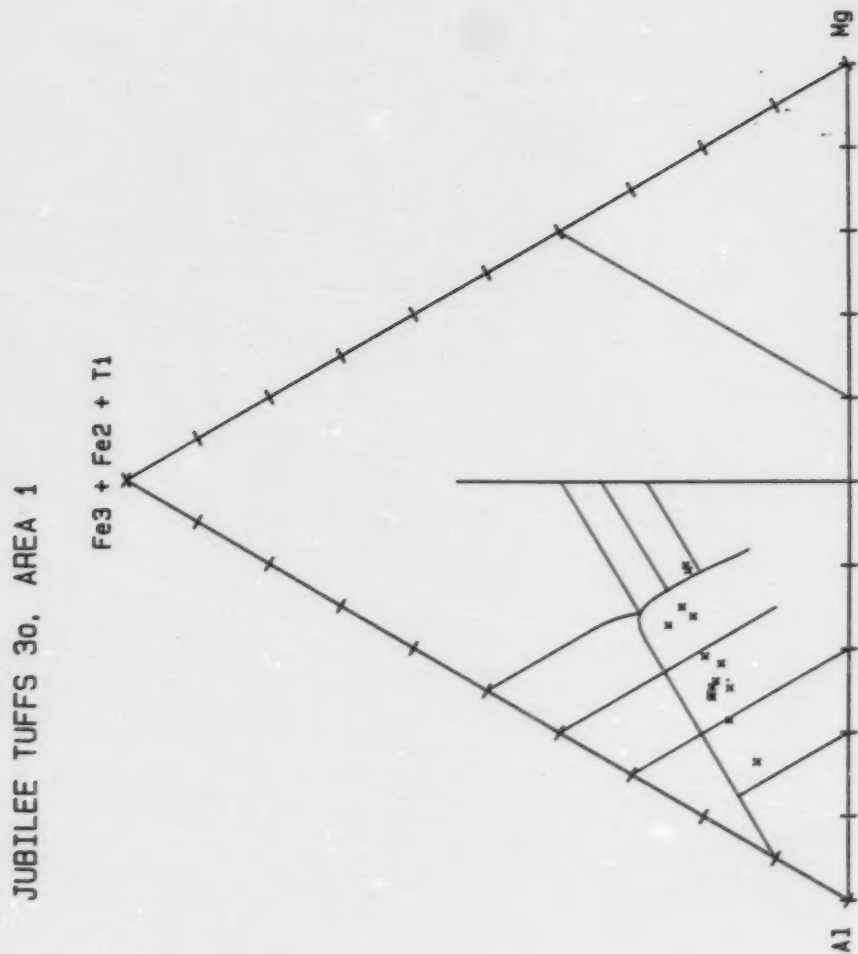


Figure 23 APM plot of Jubilee feldspar crystal tuffs

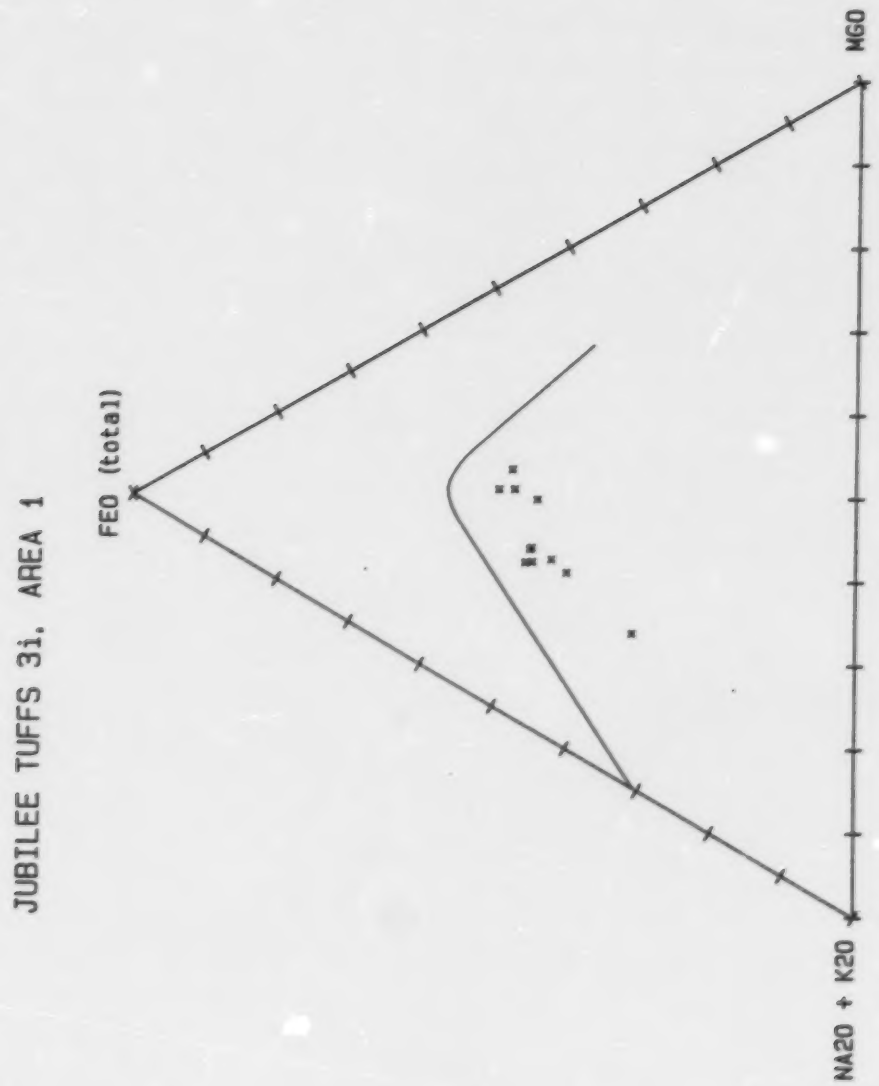


Figure 29 Jensen cation plot of Jubilee feldspar crystal tuffs

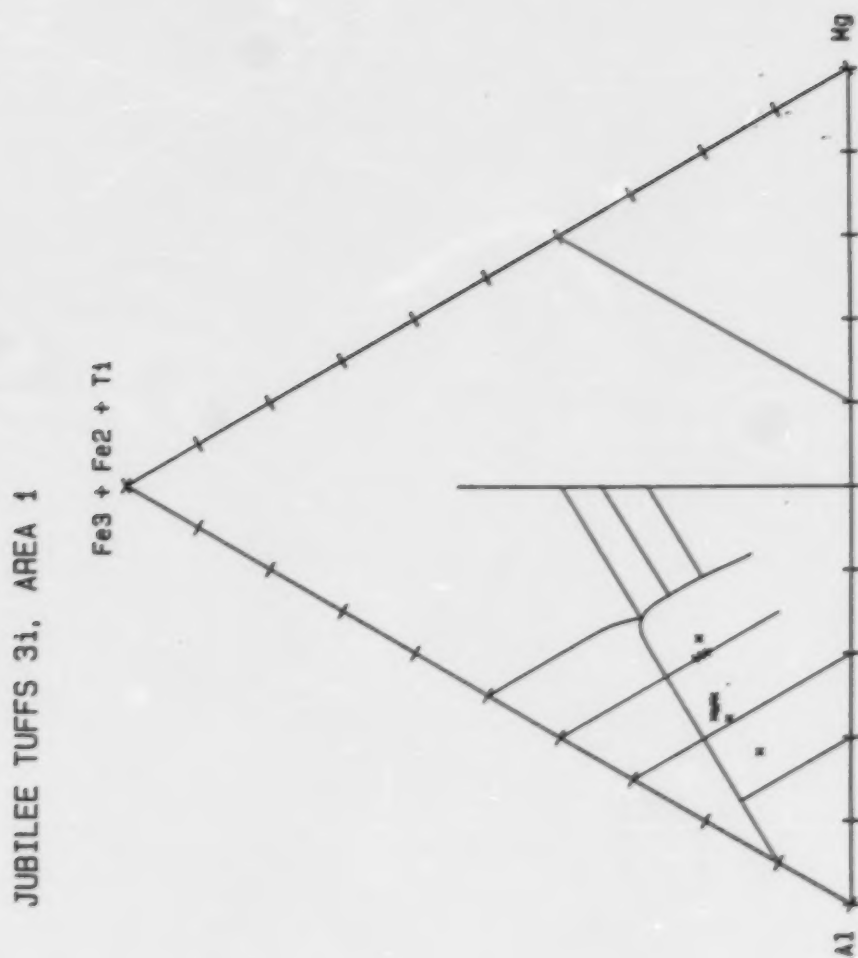


Figure 25 Jensen cation plot of all Jubilee tuffs.

X Feldspar free

ALL JUBILEE TUFF

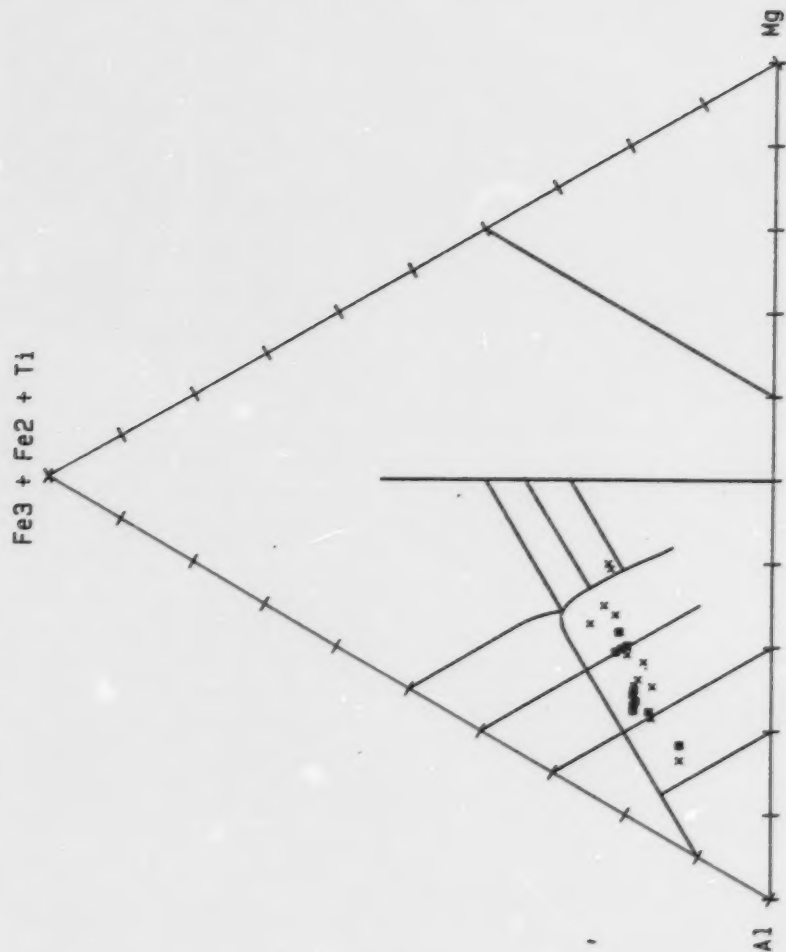


Figure 26 AFM plot of all Jubilee tuffs

X Feldspar free

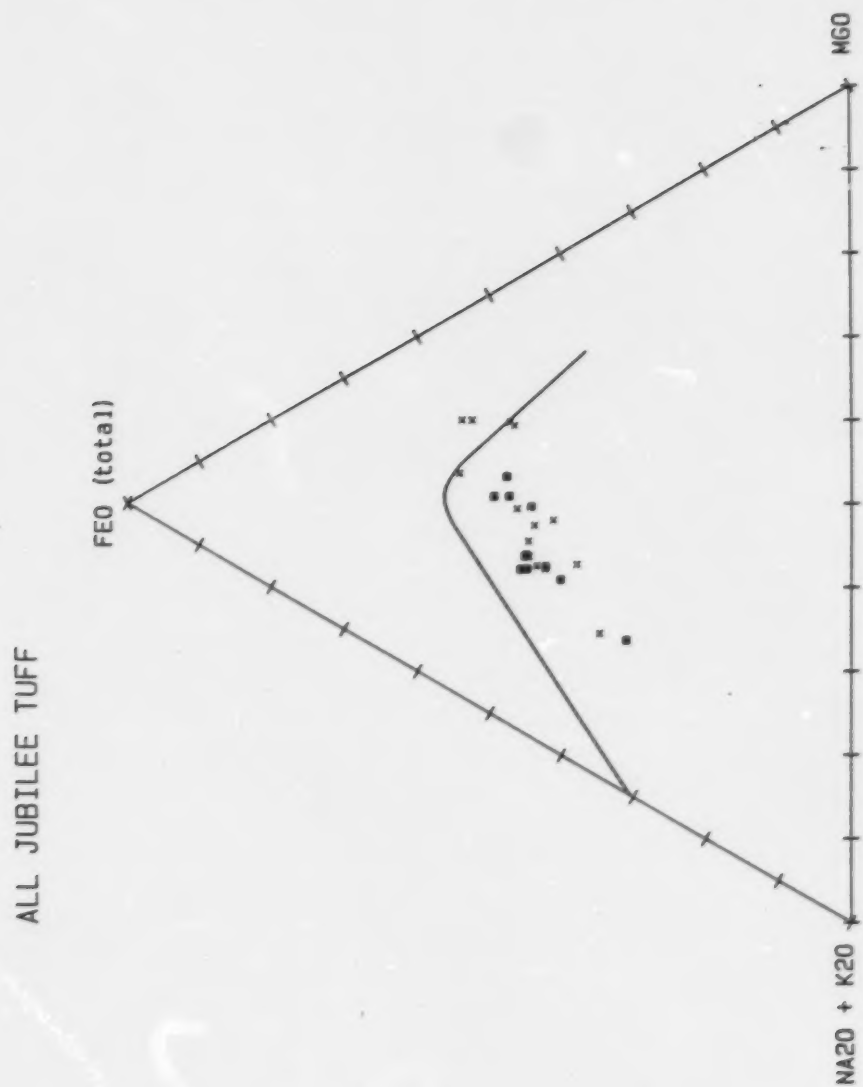


Figure 2 AFM diagram of intermediate to felsic metavolcanic rocks north of Wawa lake

INT-FELSIC VOLCANICS; N. OF WAWA LAKE; NO LUCY AREA 1

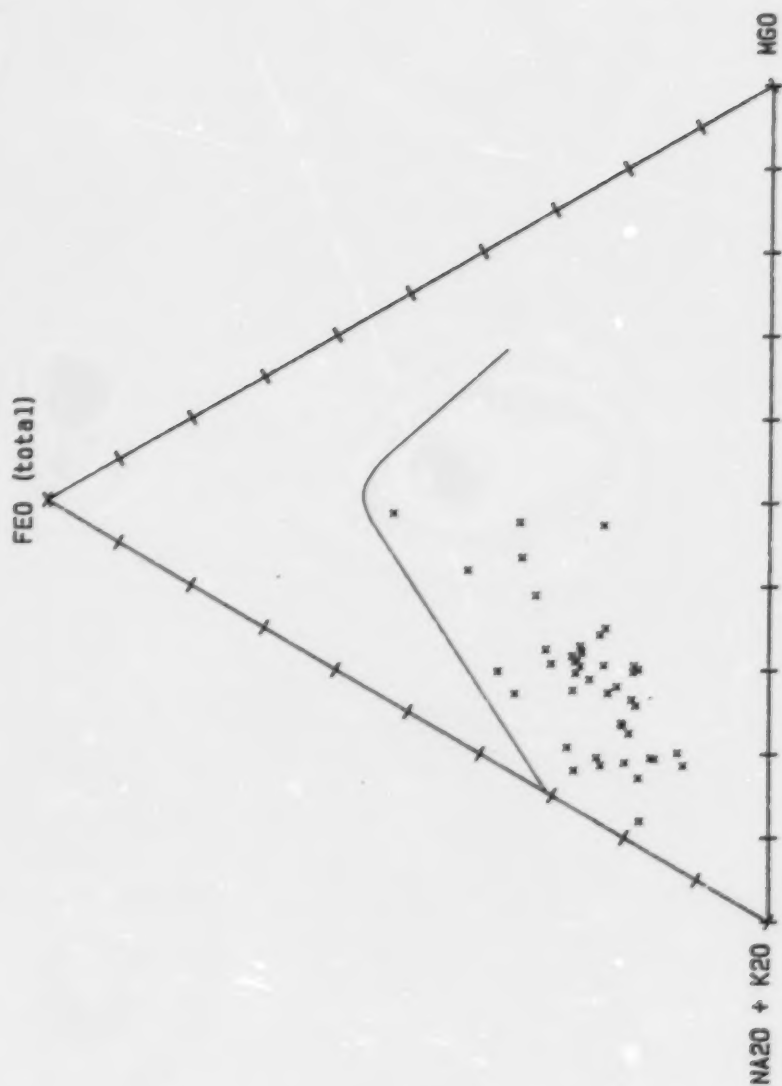


Figure 29 Jensen cation plot of intermediate to felsic metavolcanic rocks north of Wawa lake

INT-FELSIC VOLCANICS: N. OF WAWA LAKE; NO LUCY AREA 1

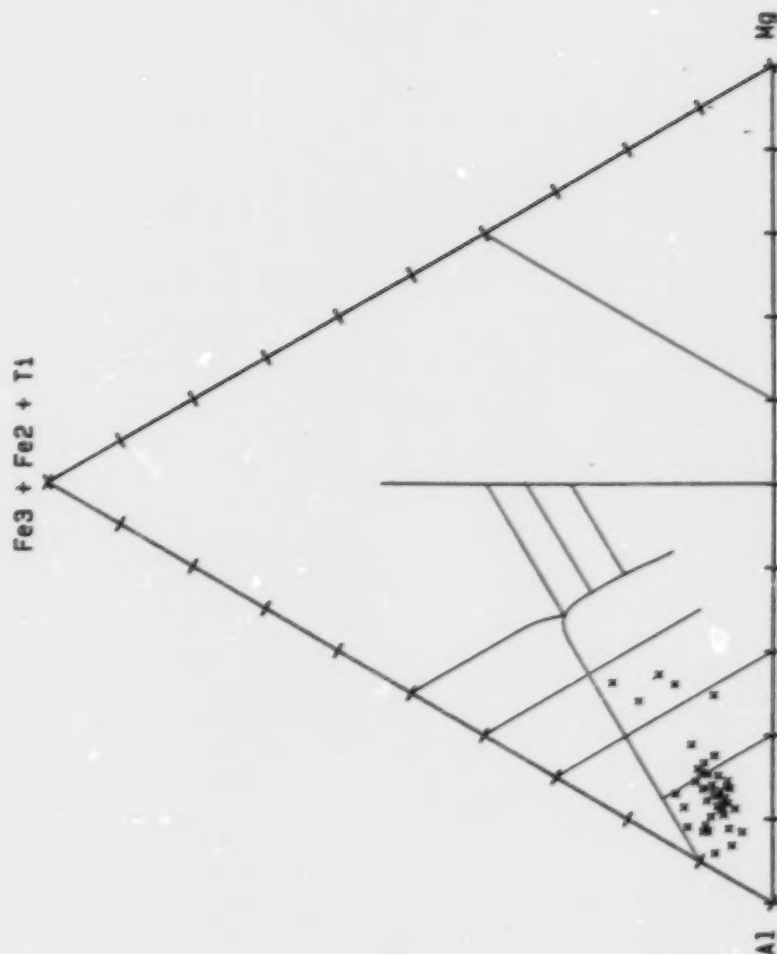
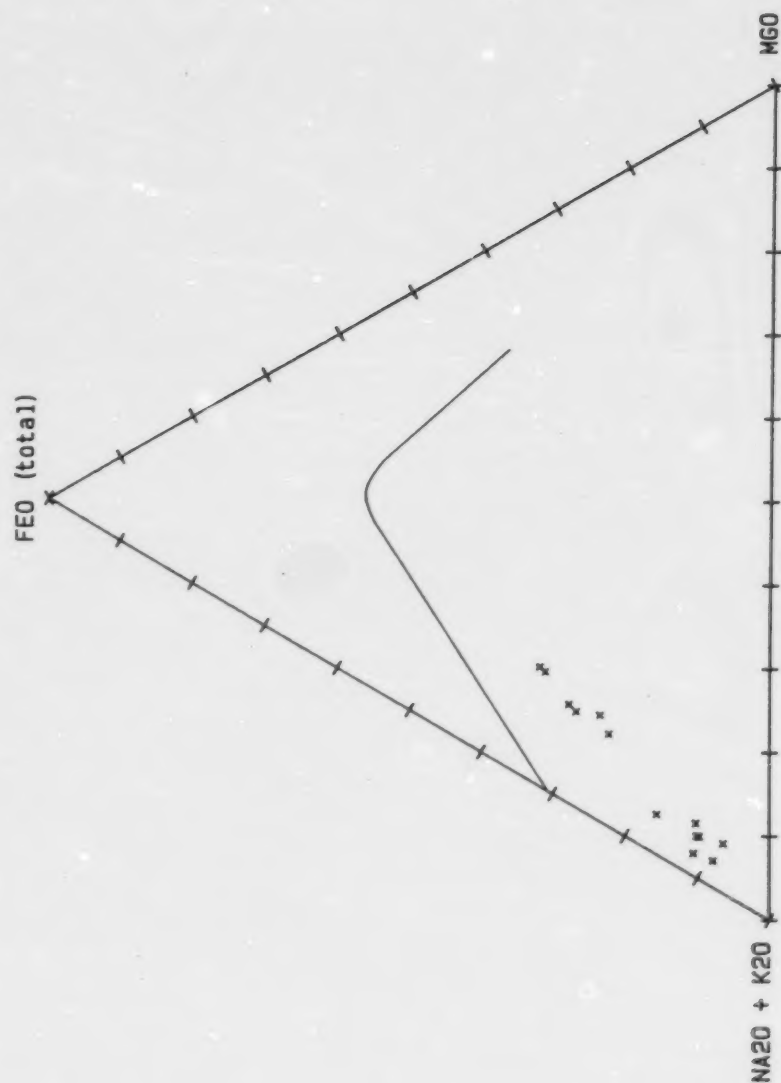


Figure 29 AFM plot of intermediate to felsic metavolcanic rocks south of Wawa lake

INT-FELSIC VOLCANICS: S. OF WAWA LAKE AREA 1



SAGE

Figure 30 Jensen cation plot of intermediate to felsic metavolcanic rocks south of Wawa lake

INT-FELSIC VOLCANICS; S. OF WAWA LAKE AREA 1

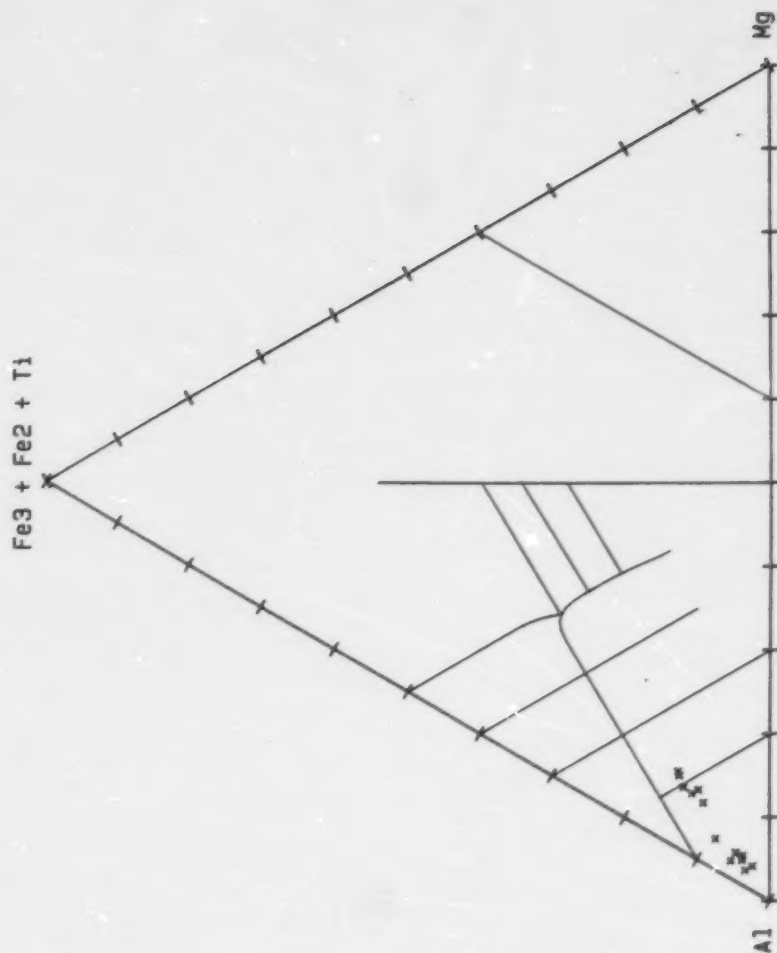


Figure 34 Jensen cation plot of cycle two intermediate to felsic
metavolcanics

INT-FELSIC VOLCANICS; CYCLE 2; MAGPIE, AREA 1

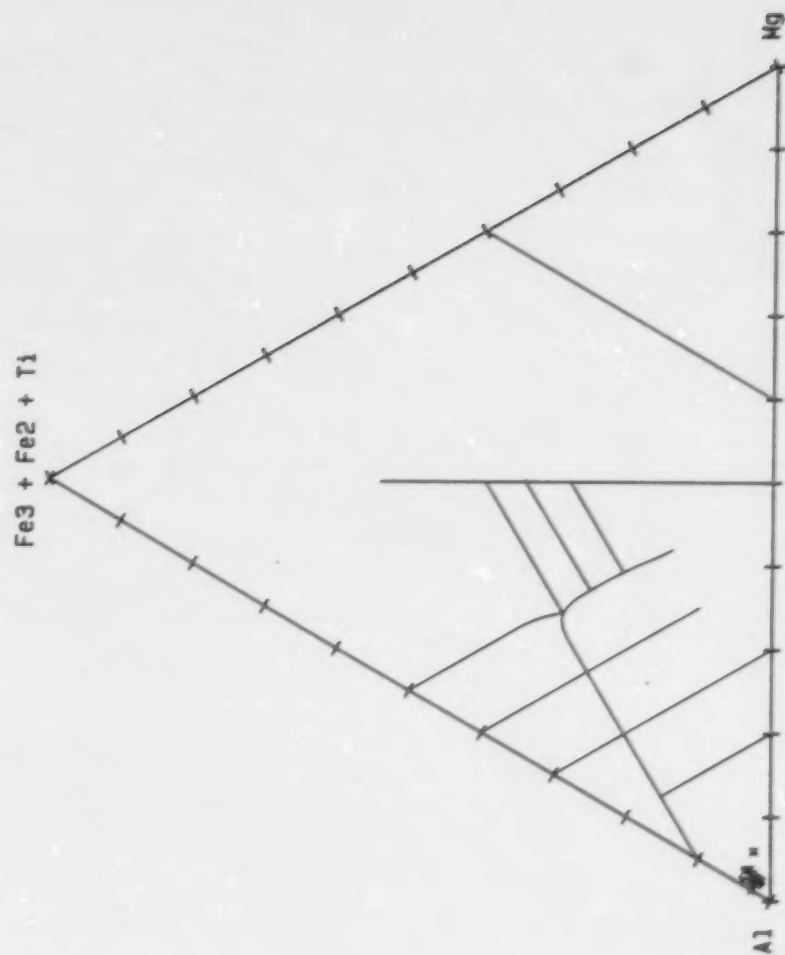


Figure 32 AFM plot of cycle two intermediates to felsic metavolcanics

INT-FELSIC VOLCANICS; CYCLE 2: MAGPIE, AREA 1

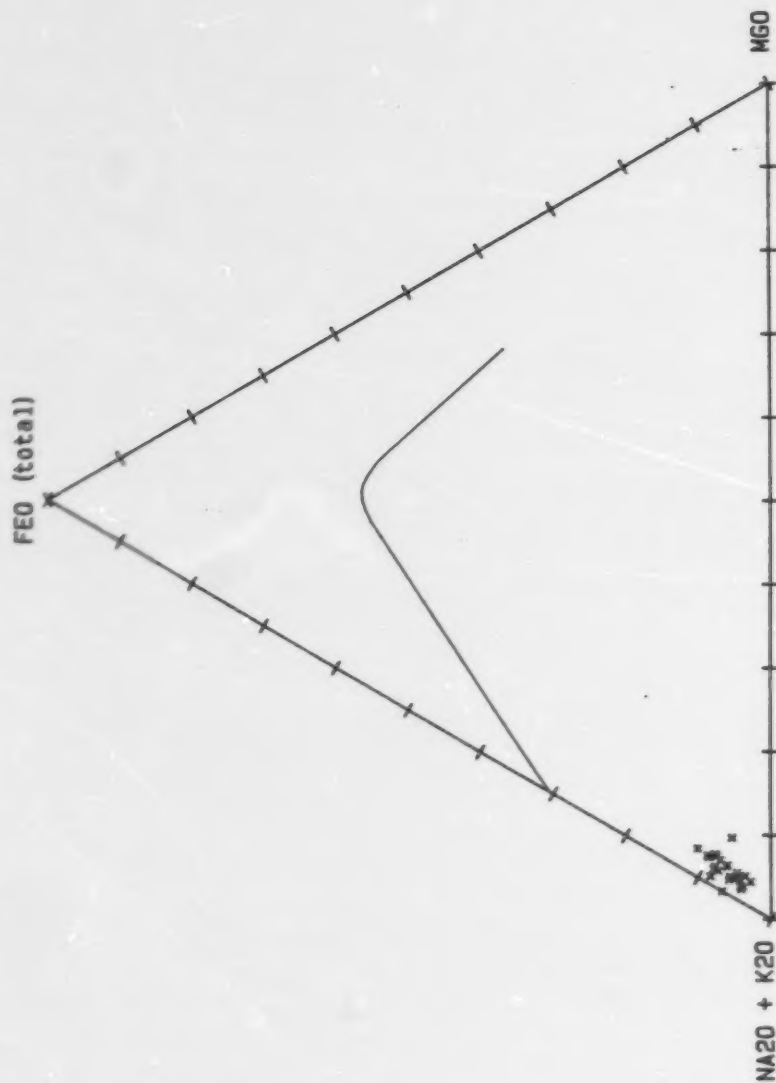
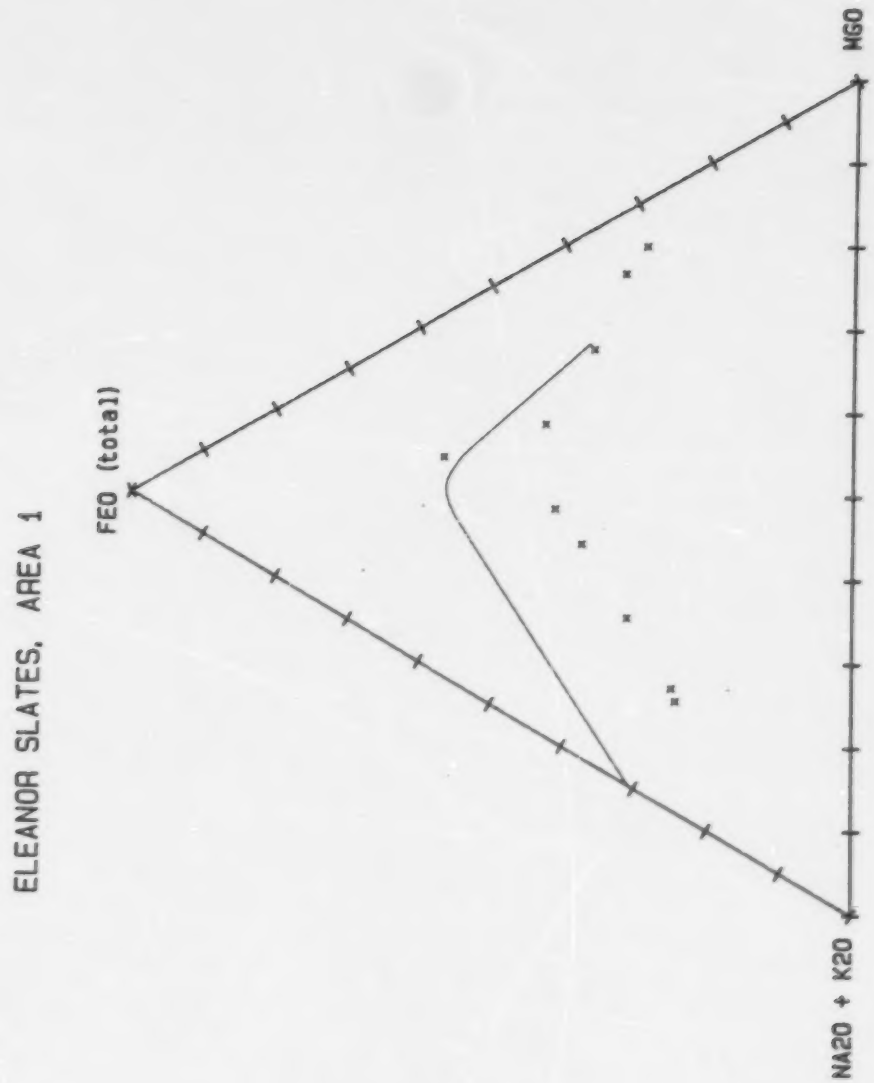


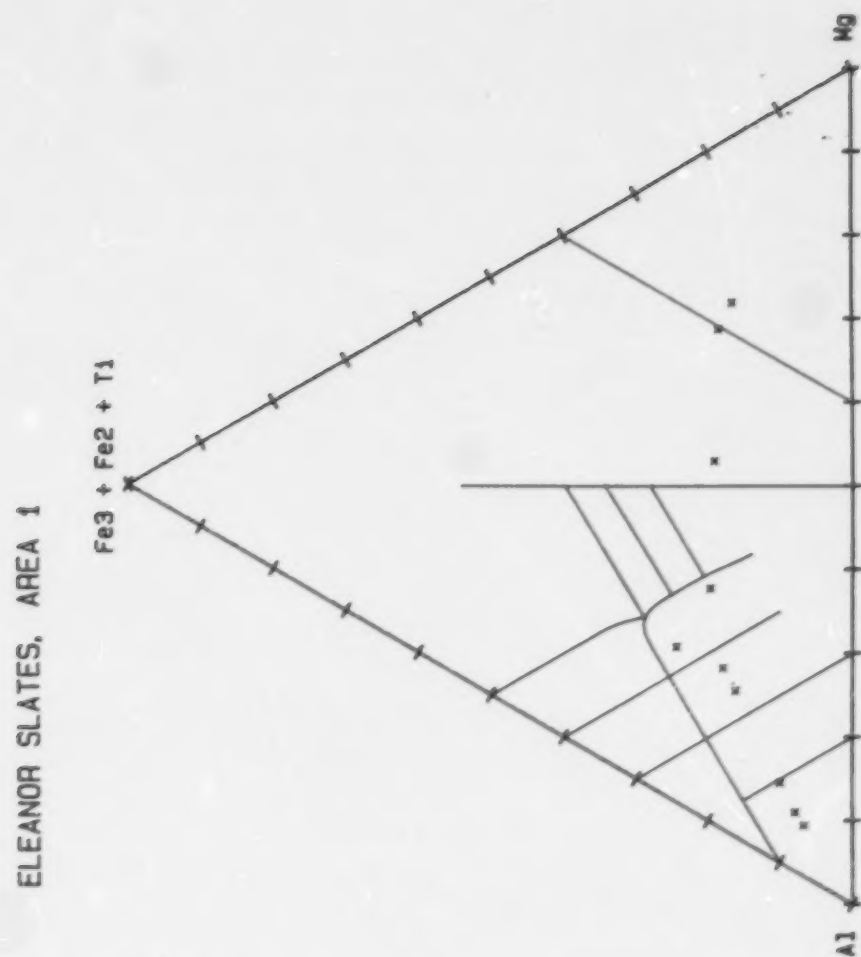
Figure 35 APM plot of Eleanor Slate metasediment samples



316

SAGE

Figure 36 Jensen cation plot of Eleanor Slate metasedimentary samples



MAFIC INTRUSIVES; NON SPECIFIC, AREA 1

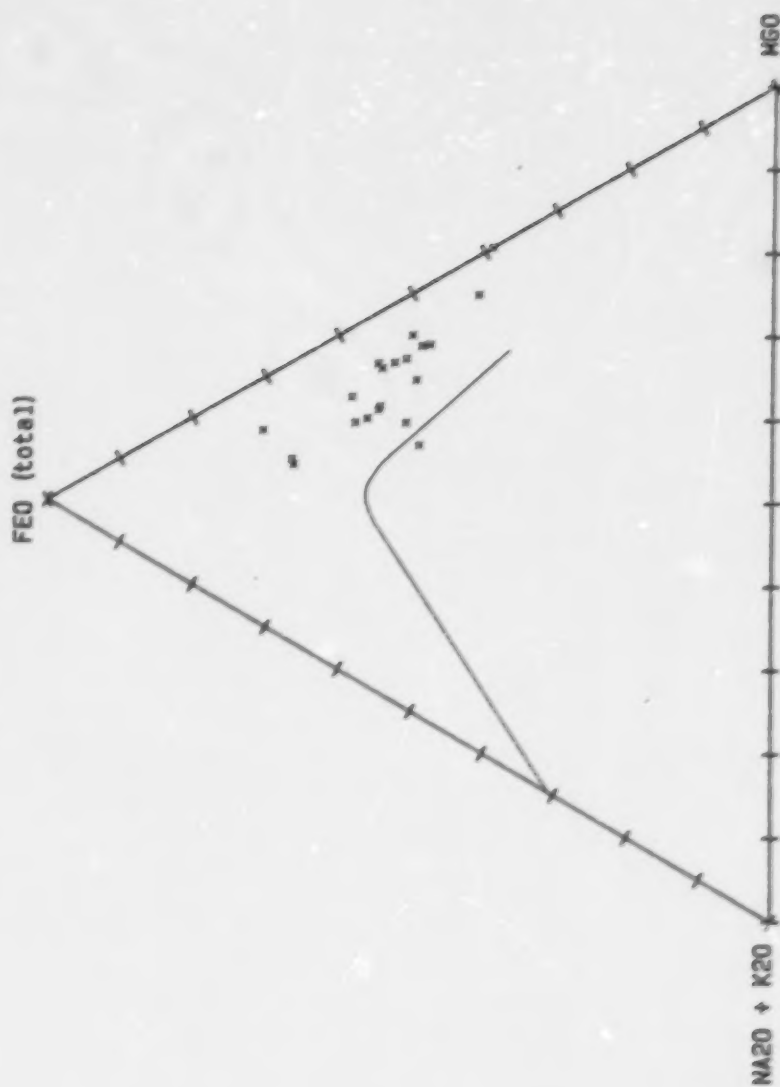


Figure 40 Jensen cation plot of miscellaneous mafic intrusive rocks

MAFIC INTRUSIVES; NON SPECIFIC. AREA 1

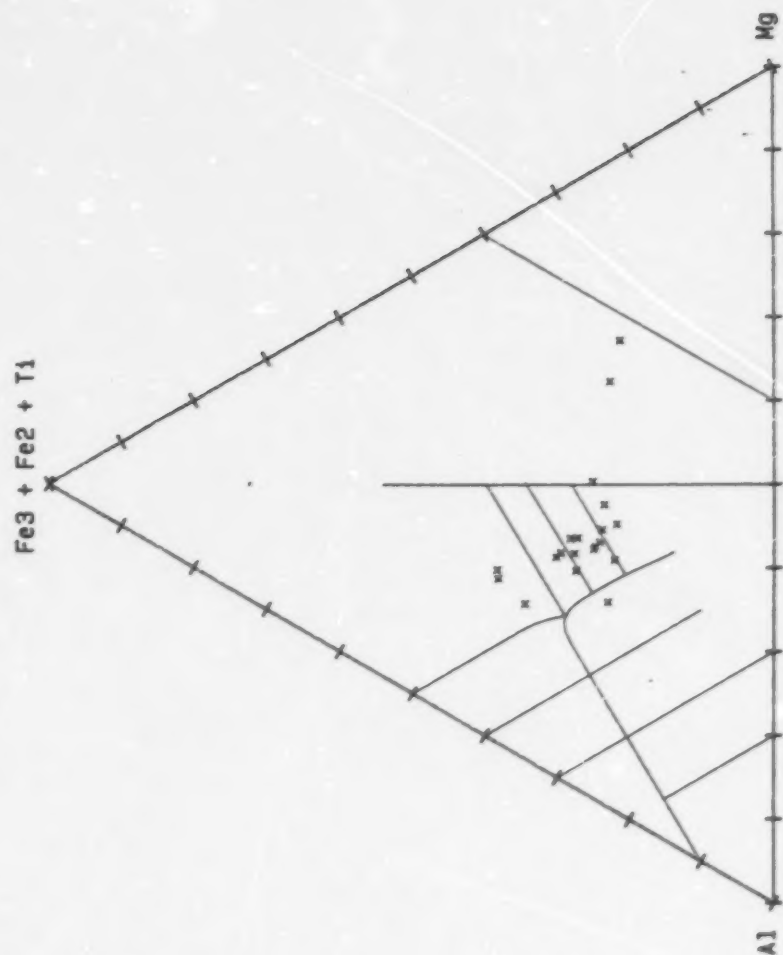
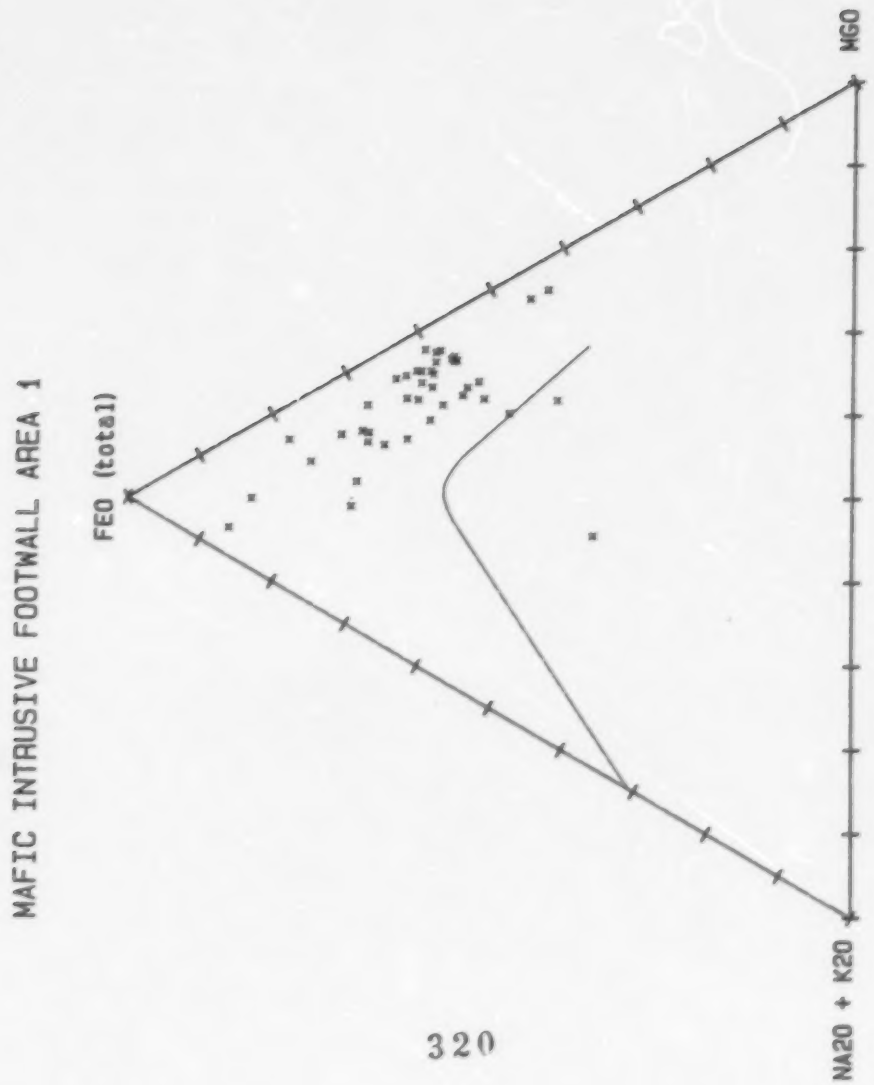


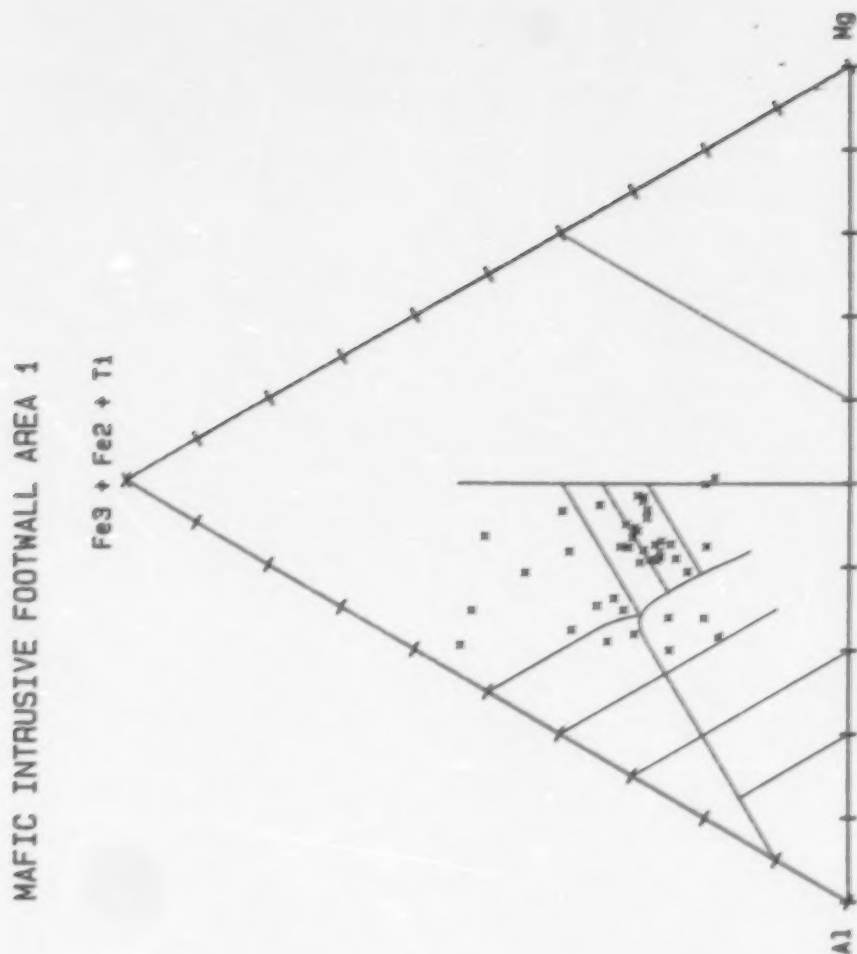
Figure 44 APM plot of footwall mafic intrusive rocks below Michipicoten Iron Formation



320

SAGE

Figure 42 Jensen cation plot of footwall mafic intrusive rocks below Michipicoten Iron Formation



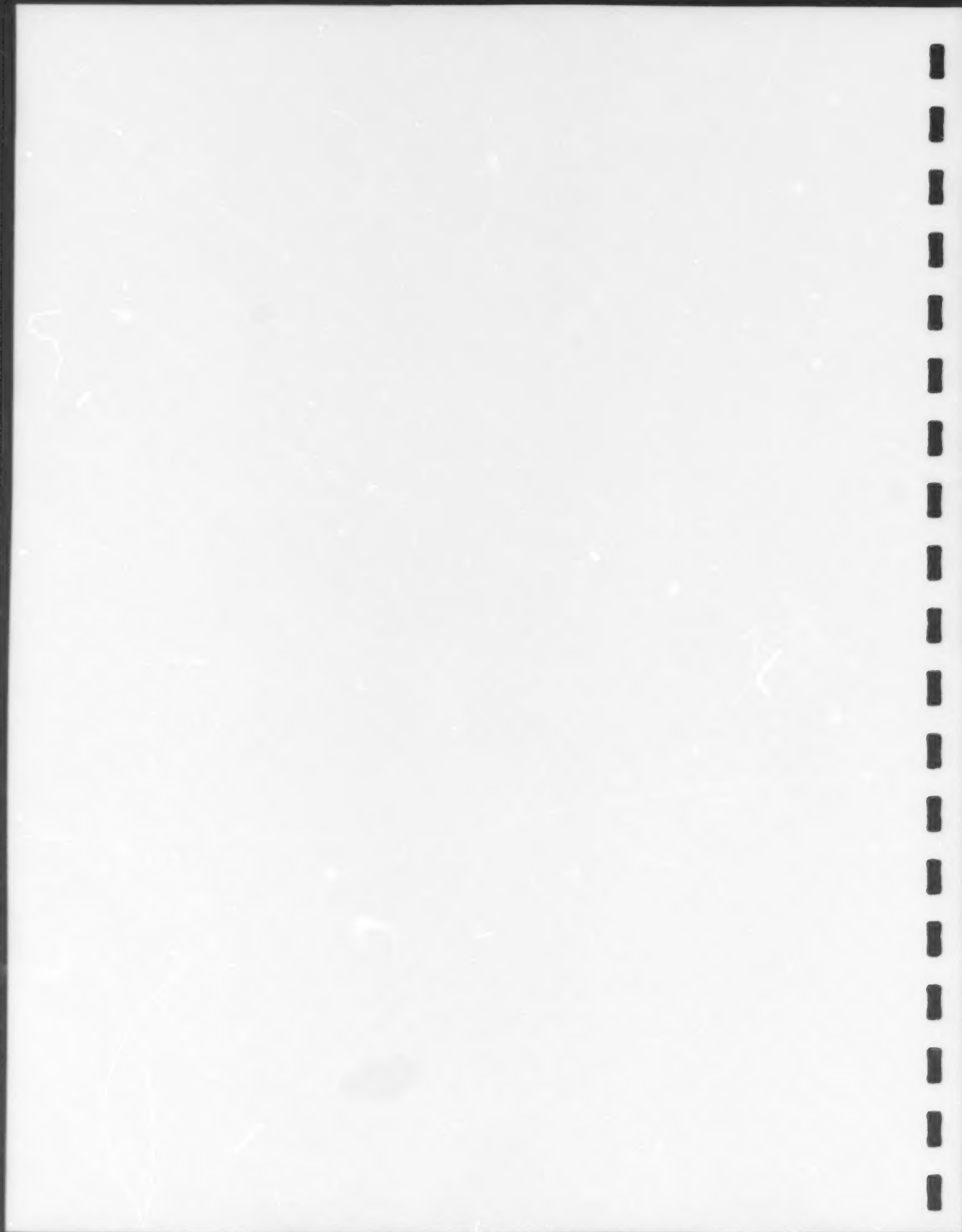


Figure 43 AFM plot of Reed lake mafic intrusive rocks

REED LAKE, MAFIC INTRUSIVES, AREA 1

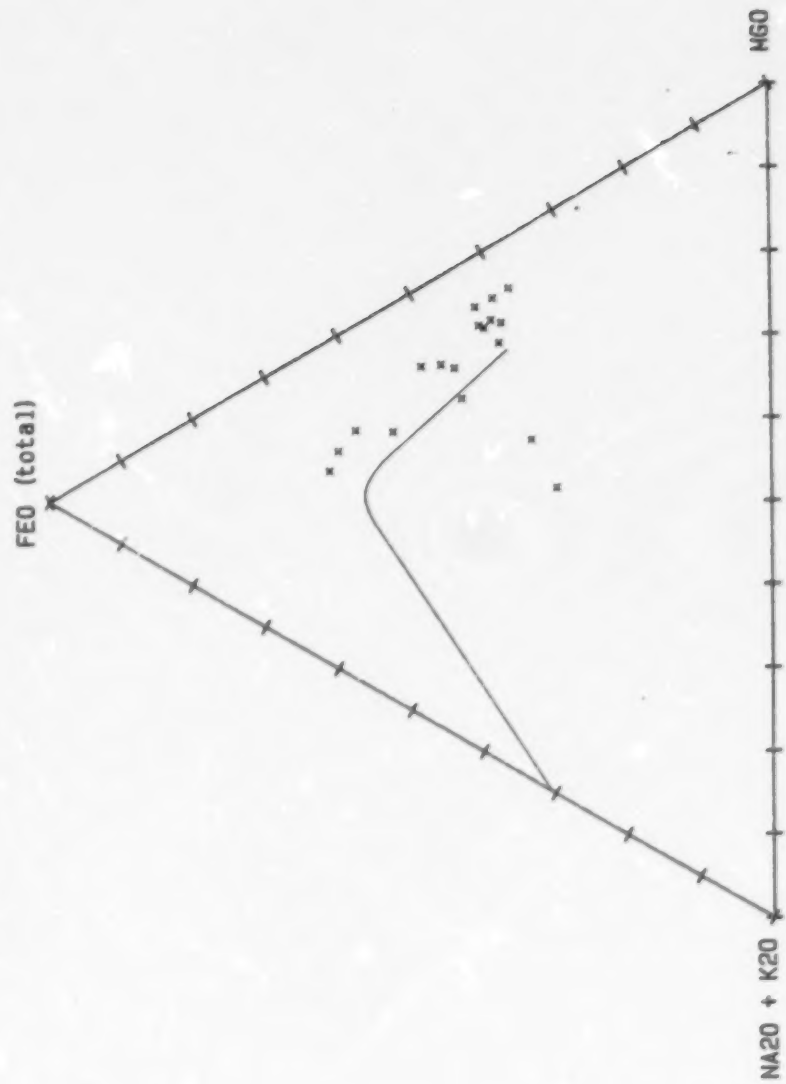


Figure 4 Jensen cation plot of Reed lake mafic intrusive rocks

REED LAKE, MAFIC INTRUSIVES, AREA 1

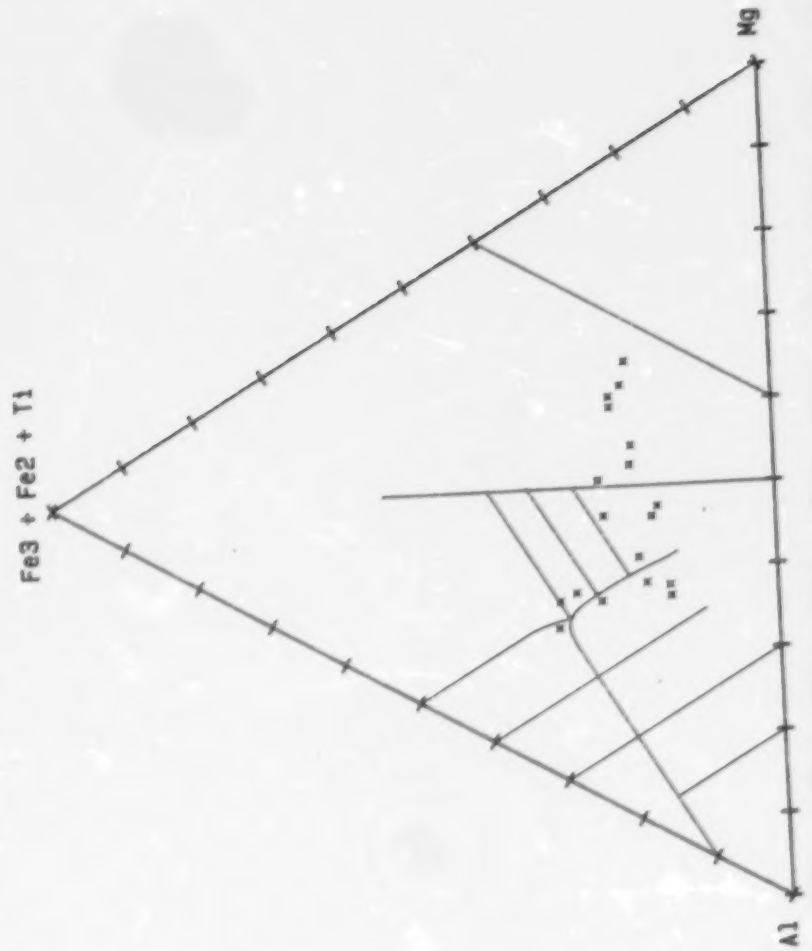


Figure 45 AFM plot of Sunrise lake mafic to ultramafic intrusion

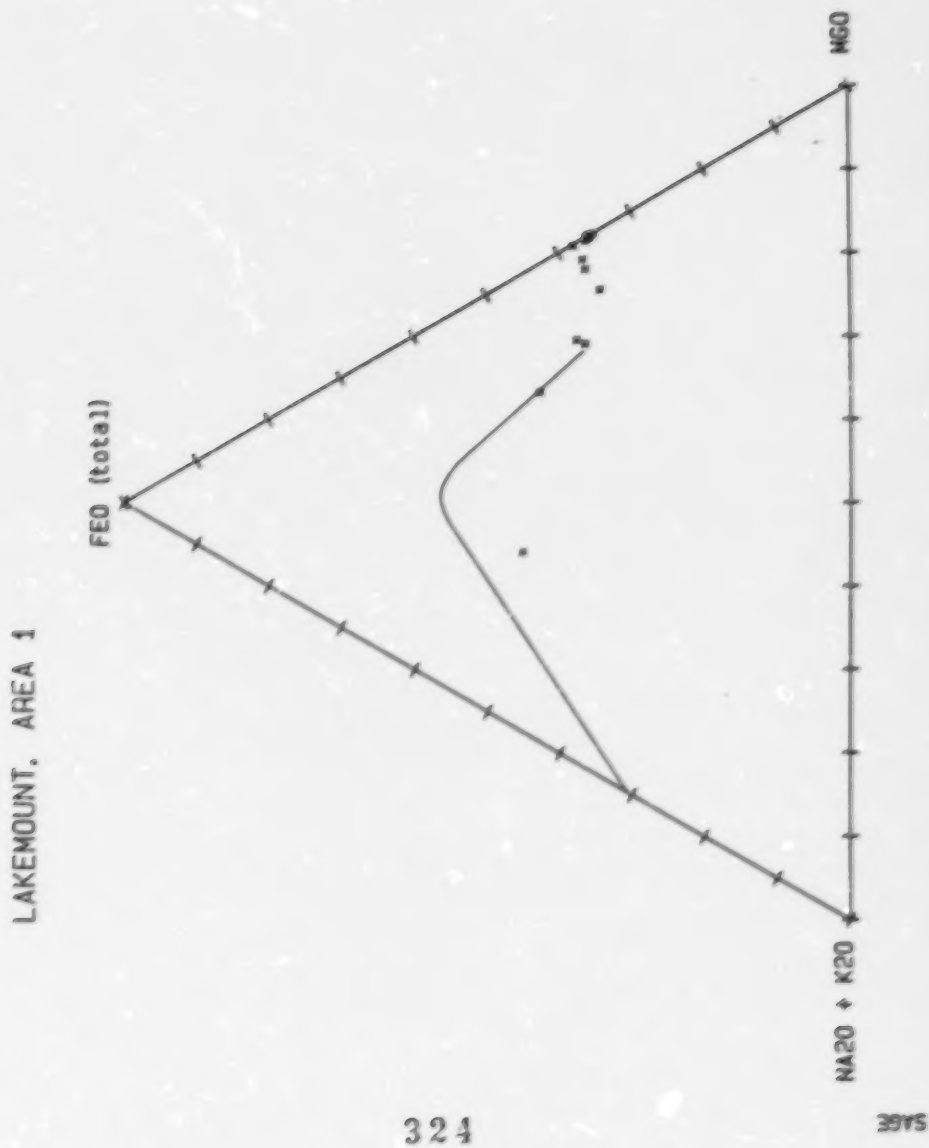


Figure 46

Jensen cation plot of Sunrise lake mafic to ultramafic intrusion

LAKEMOUNT, AREA 1

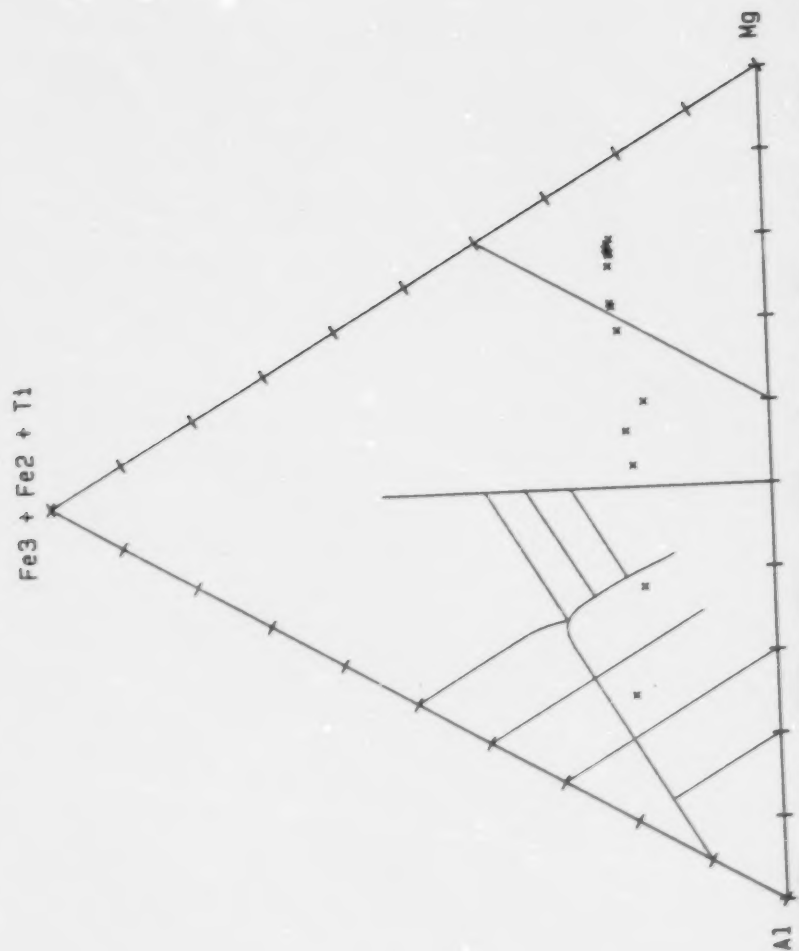


Figure 47 AFM plot of pyroxenites, Chabanel Township

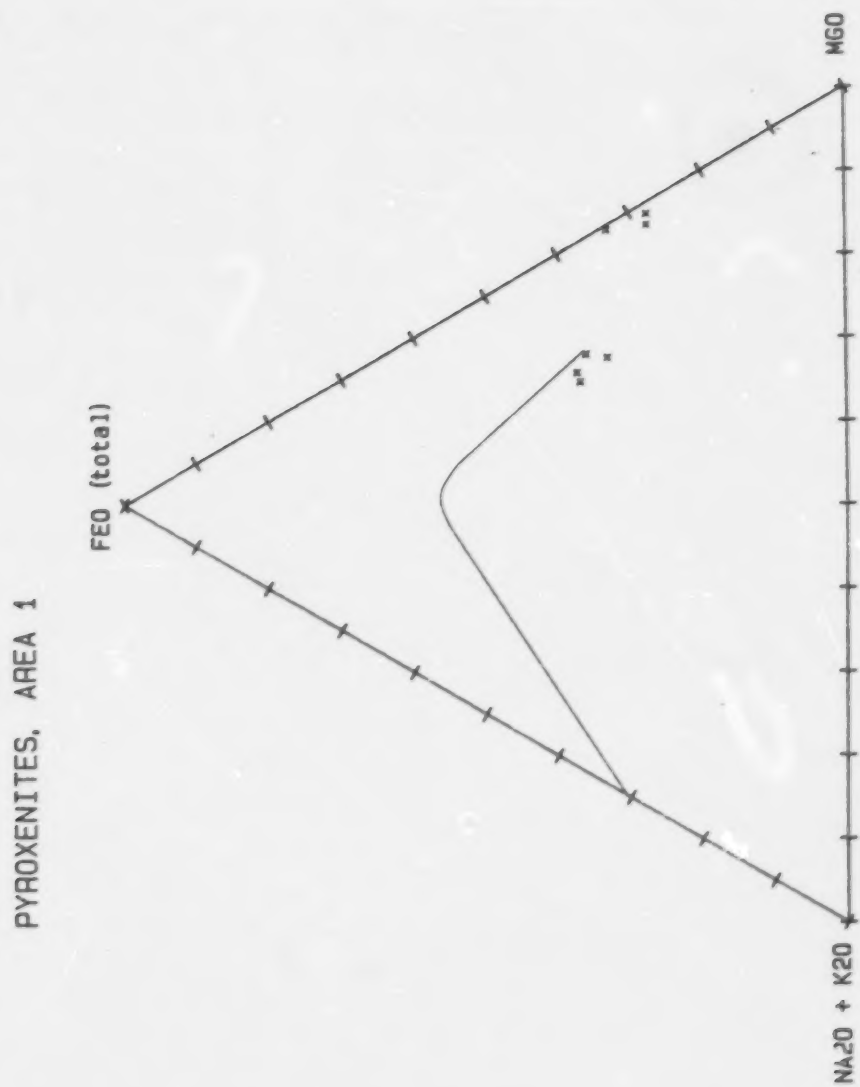


Figure 48 Jensen cation plot of proxenites, Chabanel Township

PYROXENITES. AREA 1

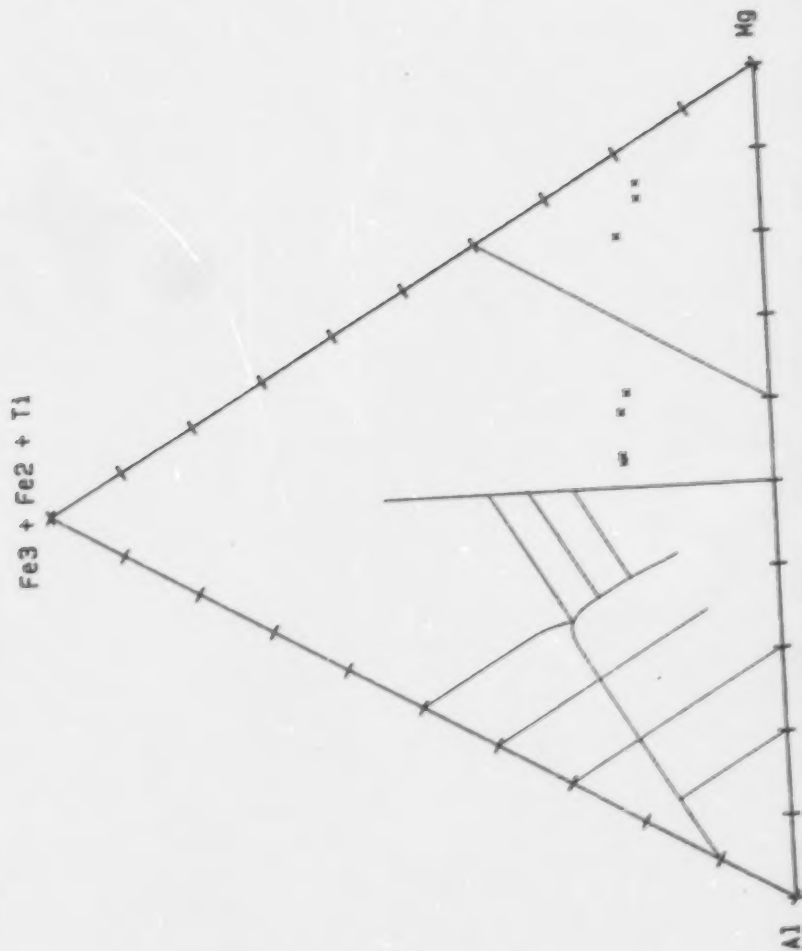


Figure 49 AFM plot of Hawk Lake Granitic Complex

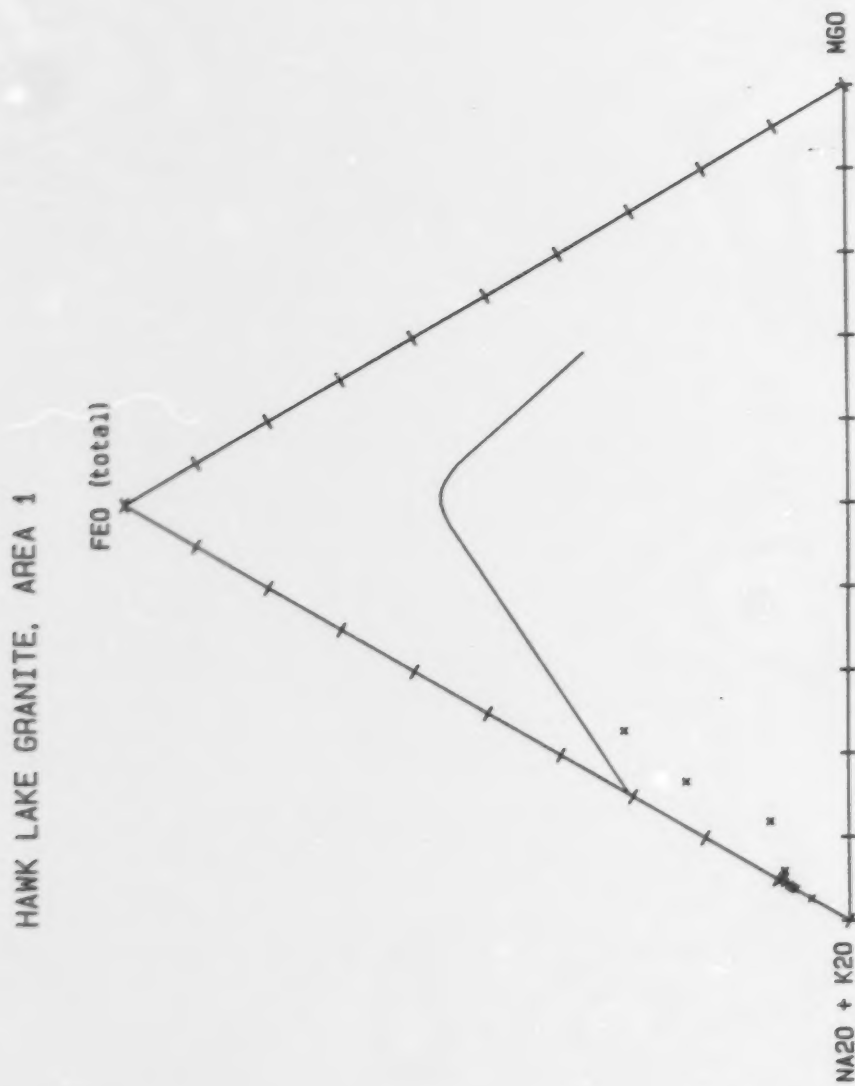


Figure 50 Jensen cation plot for Hawk Lake Granitic Complex

HAWK LAKE GRANITE, AREA 1

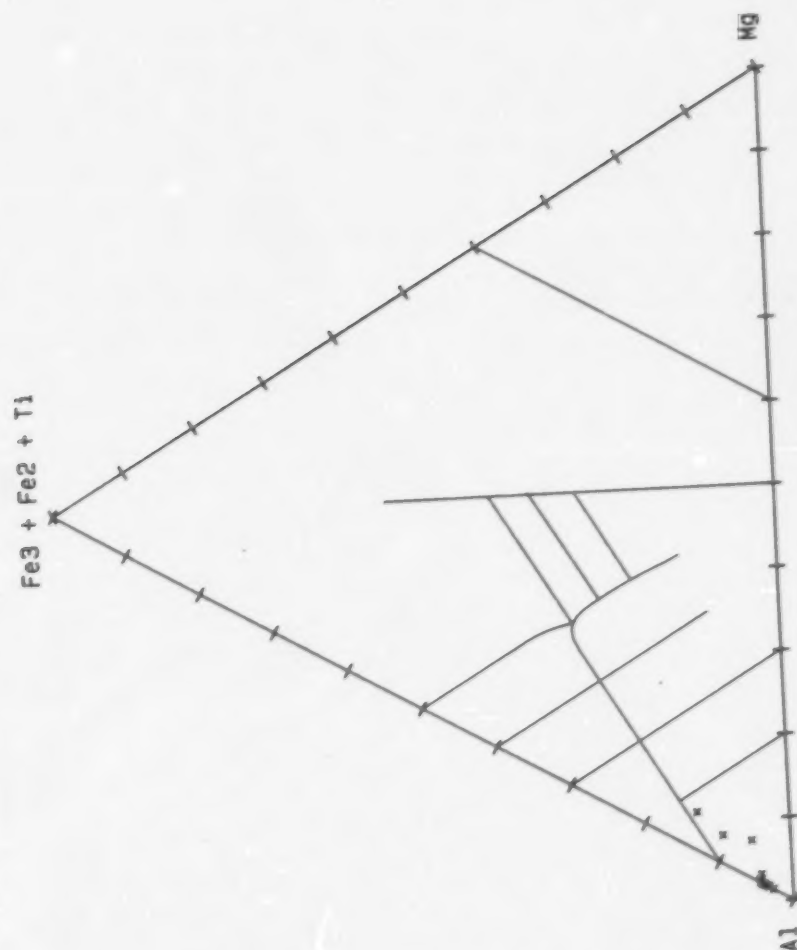


Figure 5] Streckeisen plot of norms for Hawk Lake Granitic Complex

GAP HAWK LAKE GRANITES, AREA

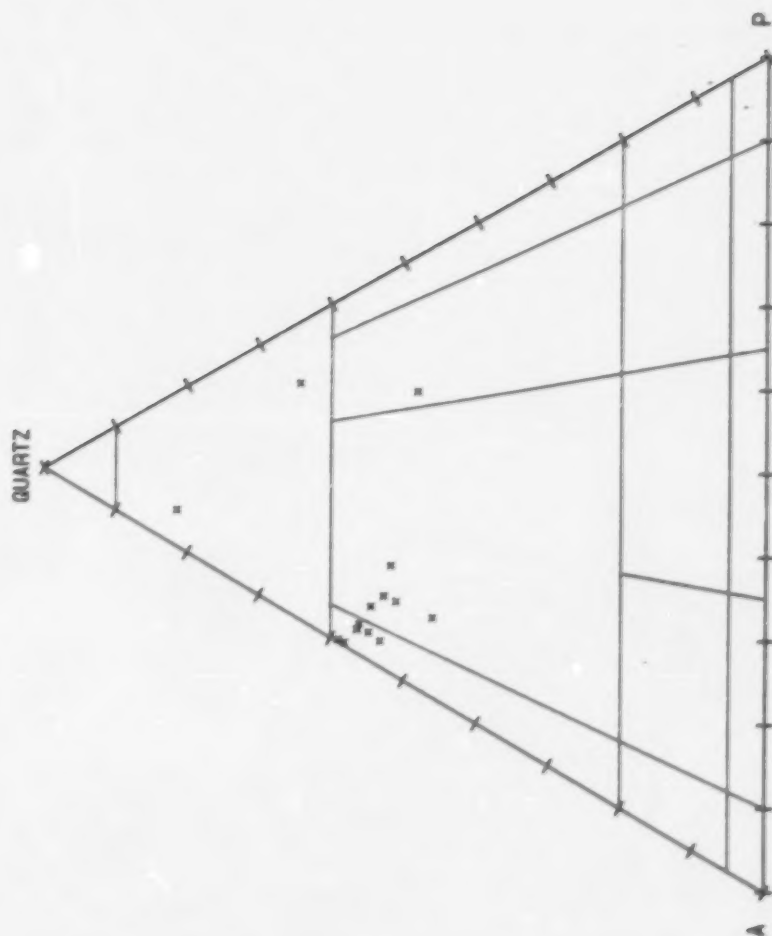


Figure 52 AFM plot of quartz-feldspar porphyry intrusive rocks

QUARTZ FELDSPAR PORPHYRIES AREA 1

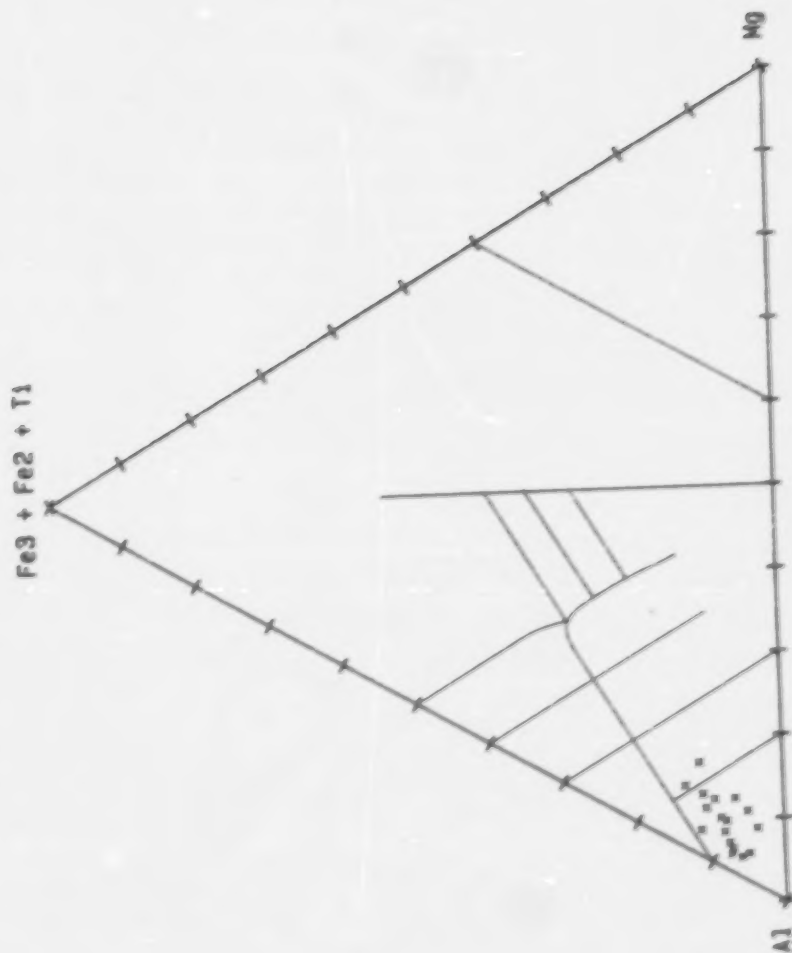
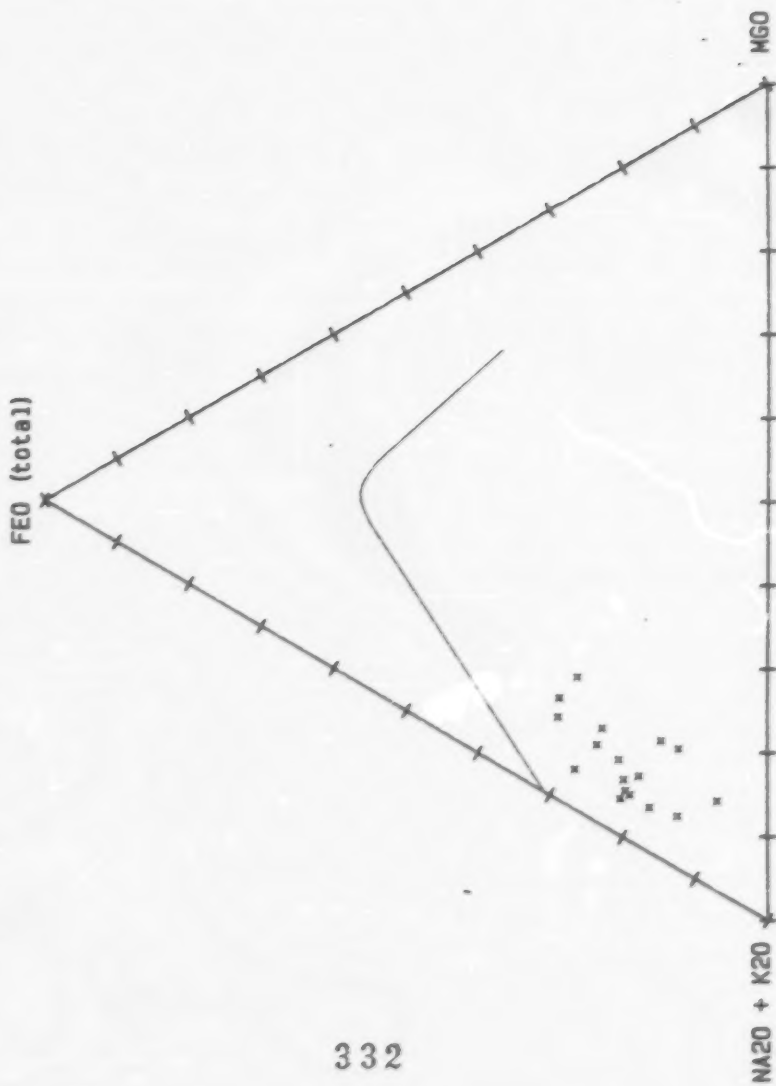


Figure 53 Jensen cation plot of quartz-feldspar porphyry intrusive rocks

QUARTZ FELDSPAR PORPHYRIES AREA 1



332

SAGE

Figure 54 Streckelsen plot using normative mineralogy of quartz-feldspar porphyry intrusive rocks

GAP QUARTZ FELDSPAR PORPHYRY INTRUSIONS, AREA I

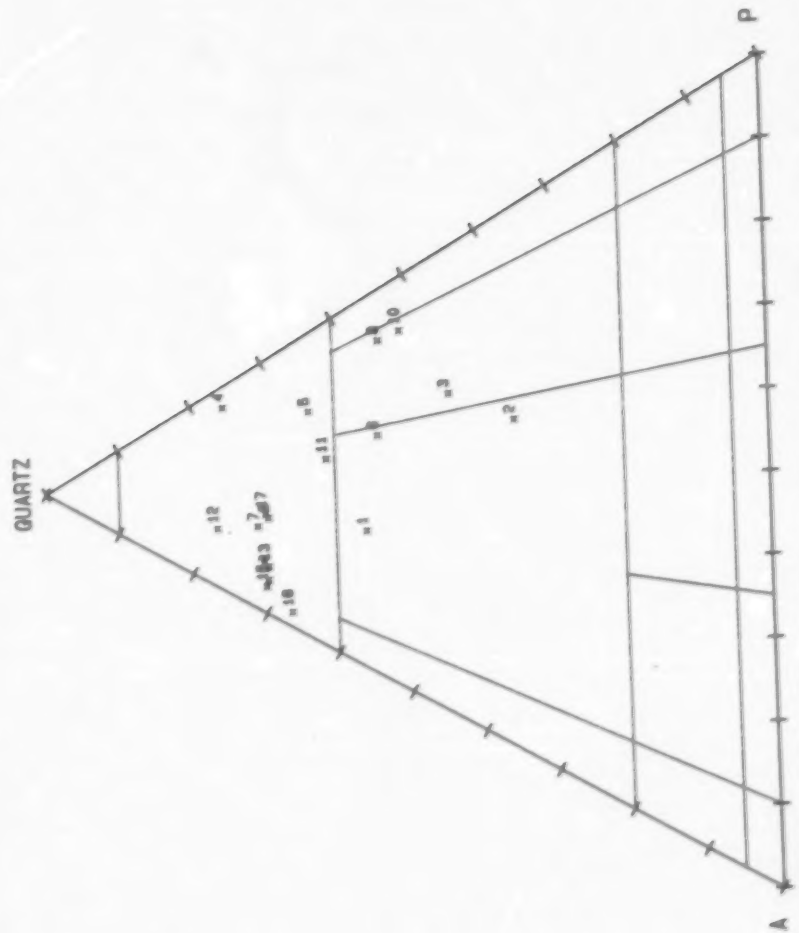


Figure 55 AFM plot for Jubilee Granitic Stock

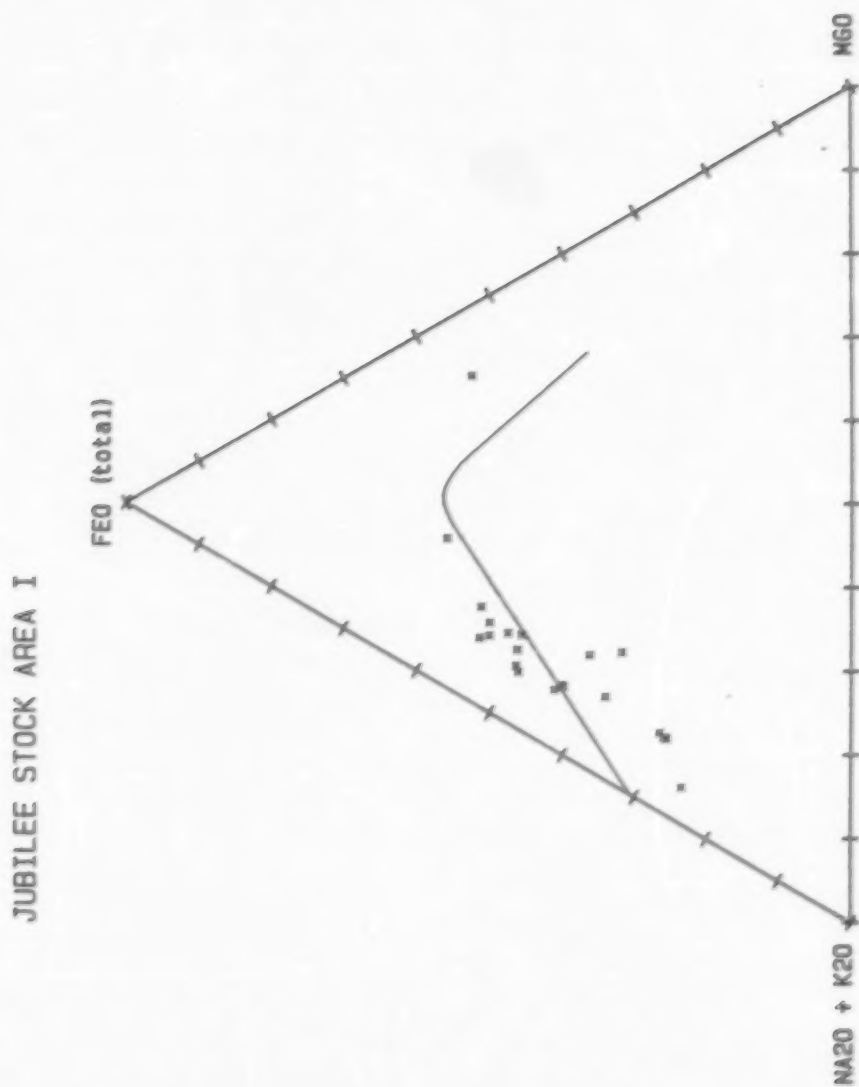


Figure 56 Jensen cation plot for Jubilee Granitic Stock

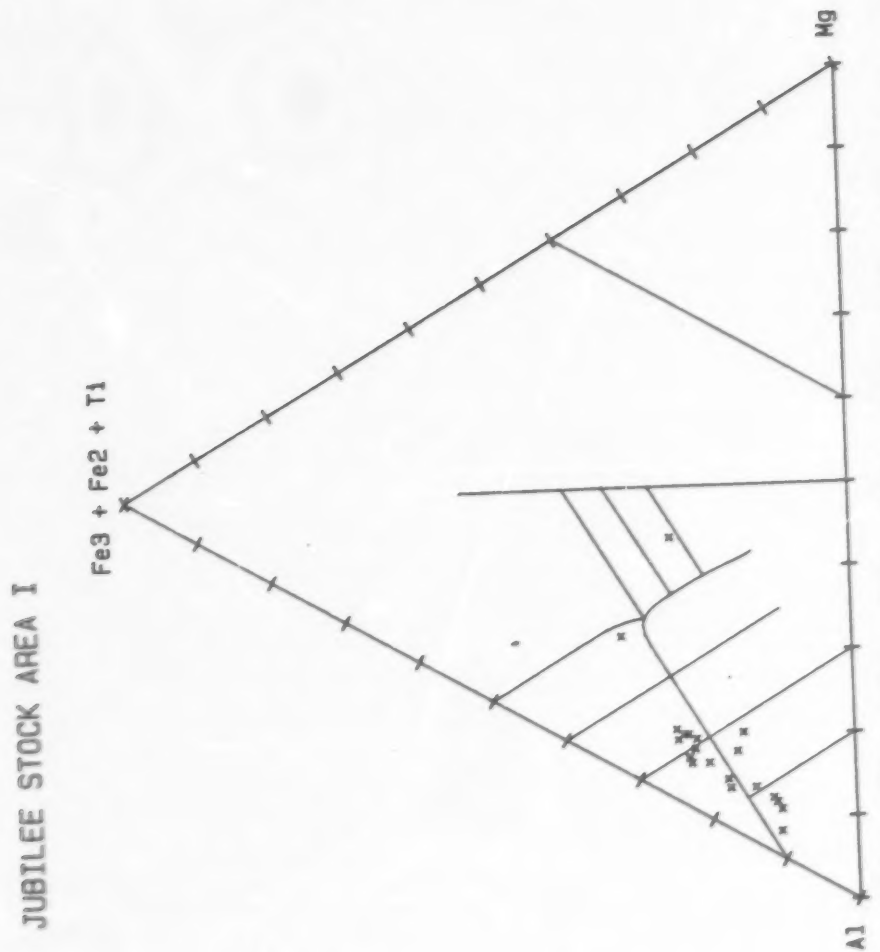


Figure 57 Streckeisen plot of normative mineralogy of Jubilee Granitic Stock

GAP JUBILEE STOCK, AREA I

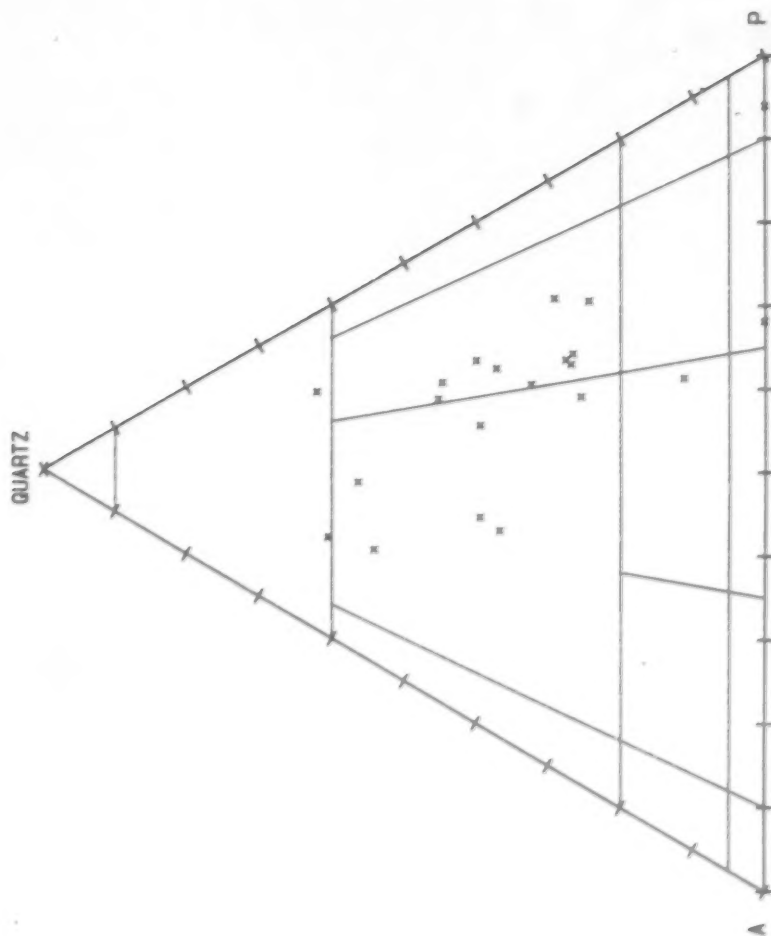


Figure 29 Jensen cation plot of cycle one mafic and felsic metavolcanics

JENSON PLOT OF CYCLE I MAFIC AND FELSIC METAVOLCANICS, AREA I

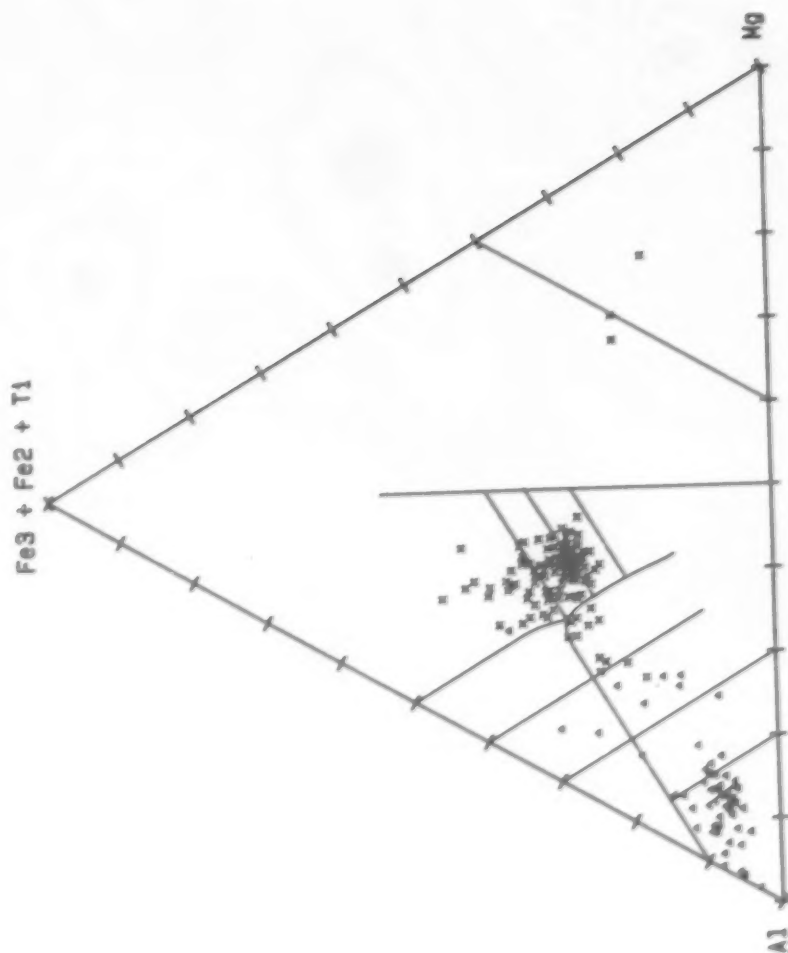


Figure 60 AFM plot of cycle one mafic and felsic metavolcanics

AFM PLOT OF CYCLE I MAFIC AND FELSIC METAVOLCANICS, AREA I

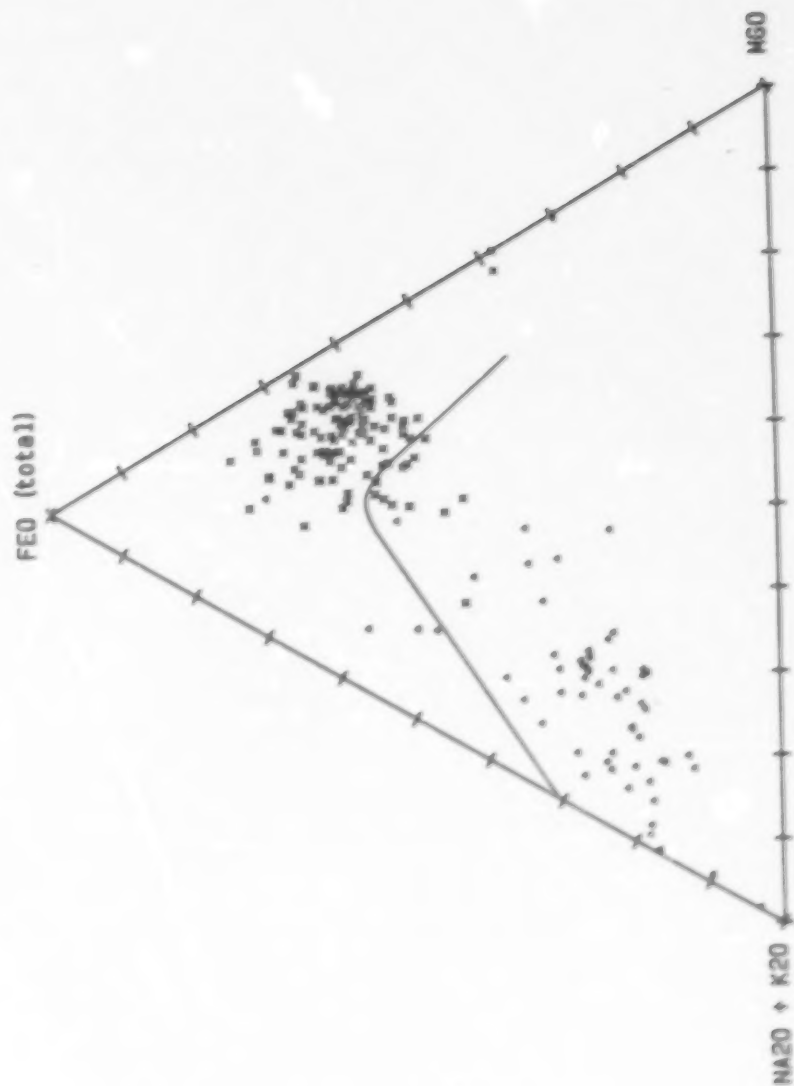


Figure 61 Jensen cation plot of felsic and mafic volcanic rocks of cycle two

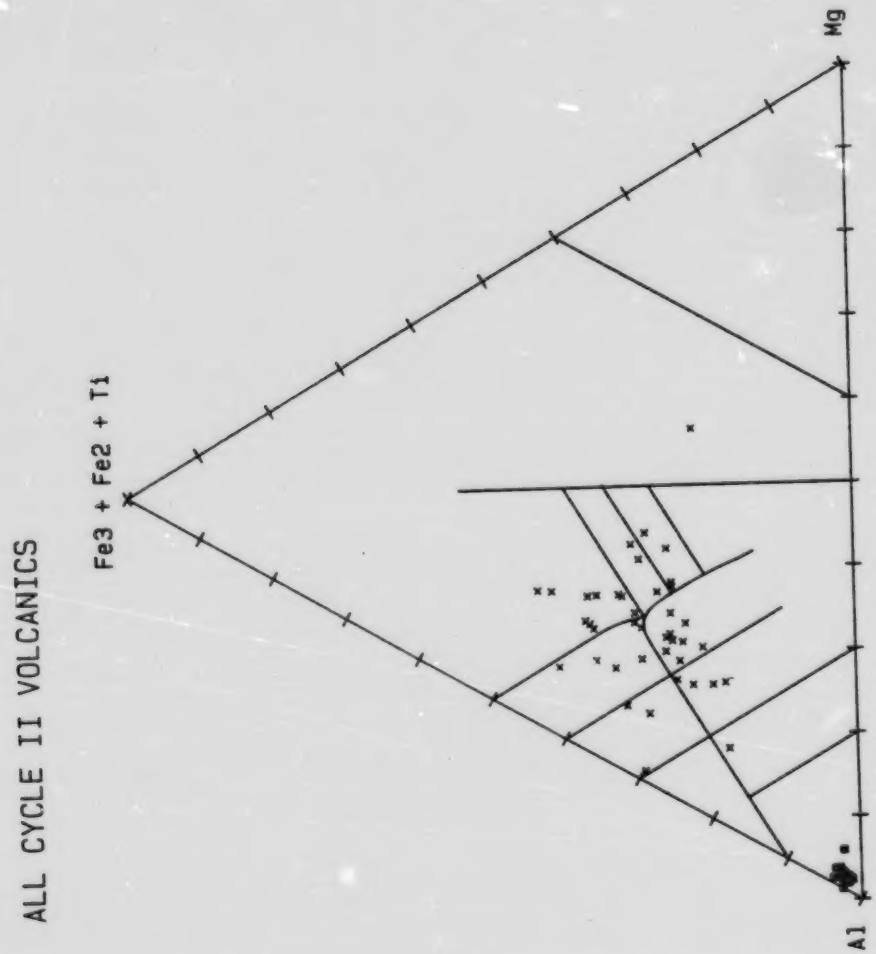
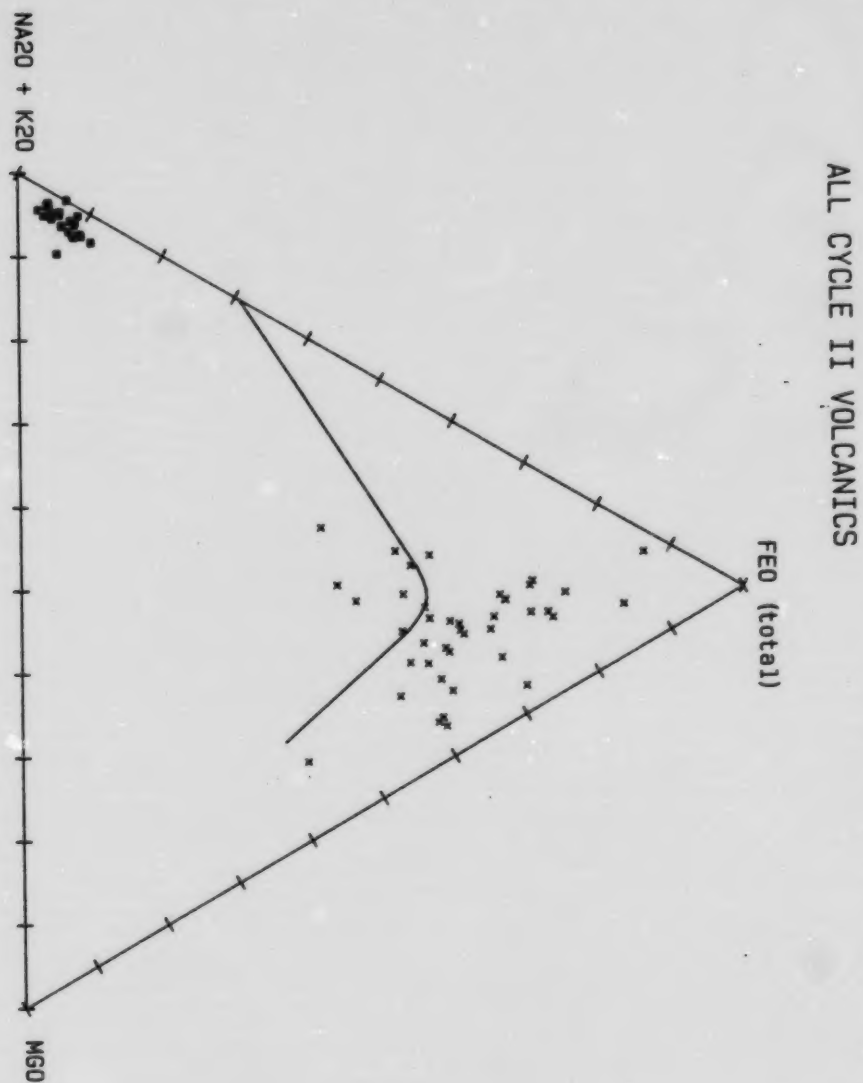
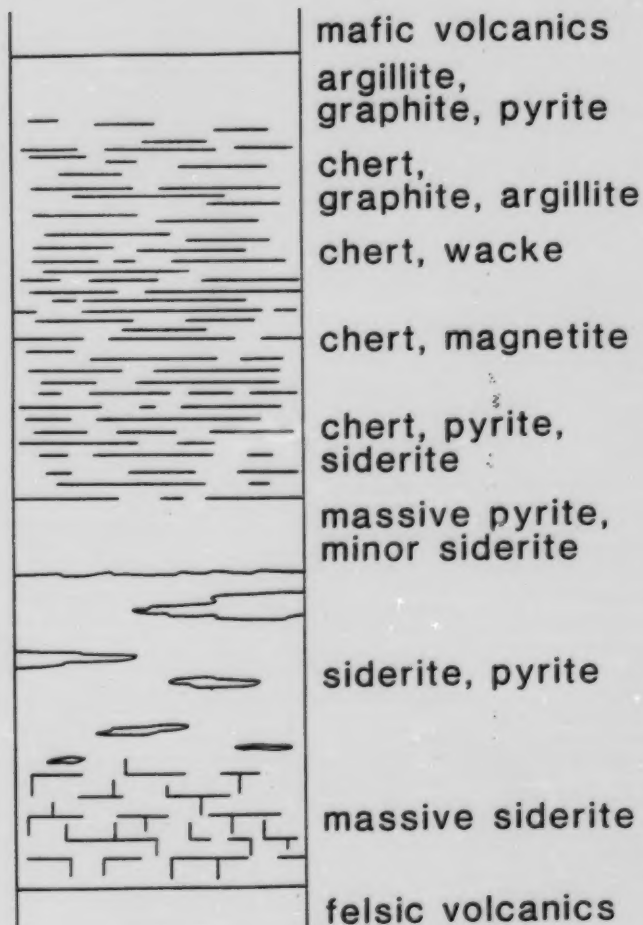


Figure 62 AFM plot of felsic and mafic metavolcanic rocks of cycle two

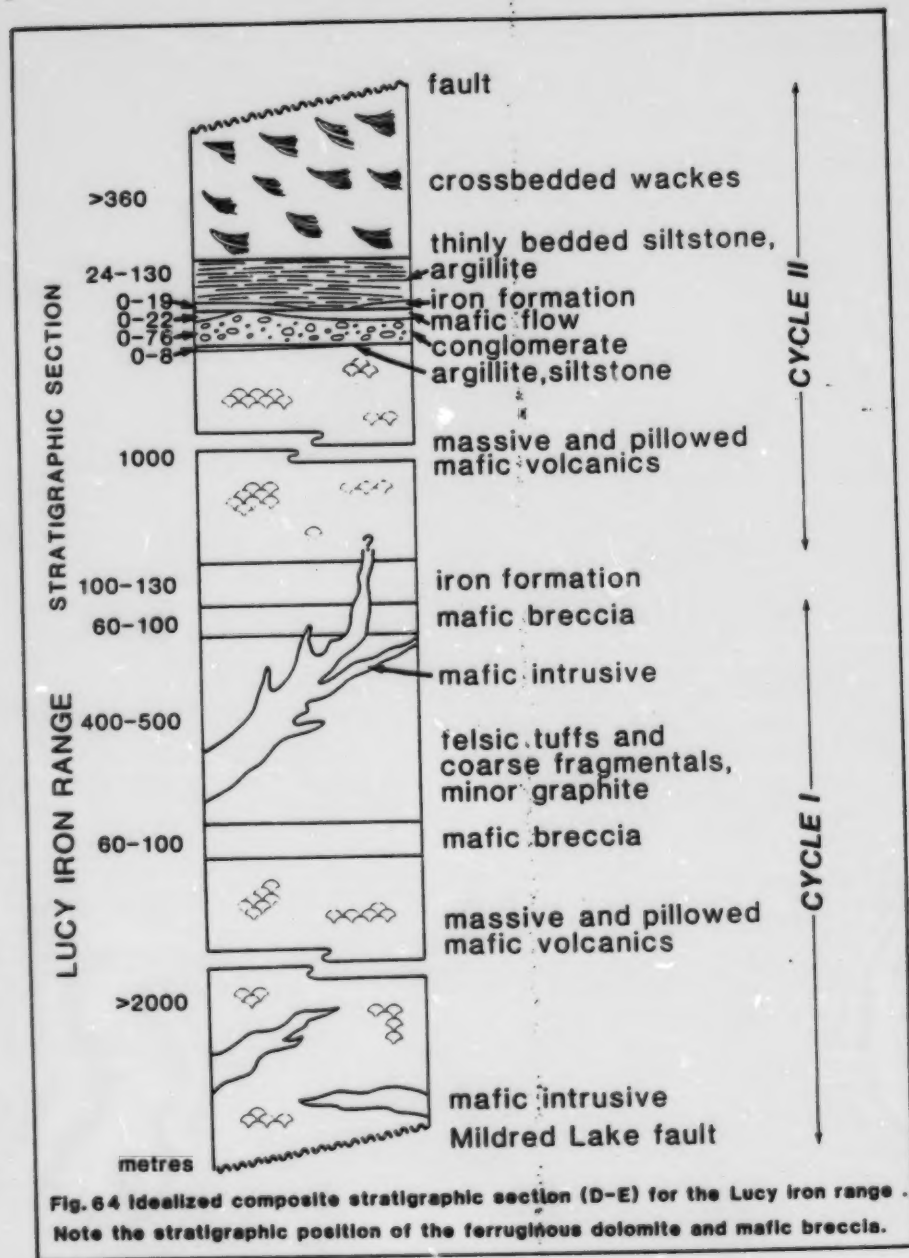
SAGE





MICHIPICOTEN TYPE IRON FORMATION

Fig. 63 Idealized schematic of facies in the Michipicoten iron formation. Note sharp upper and lower contacts and gradational internal contacts.



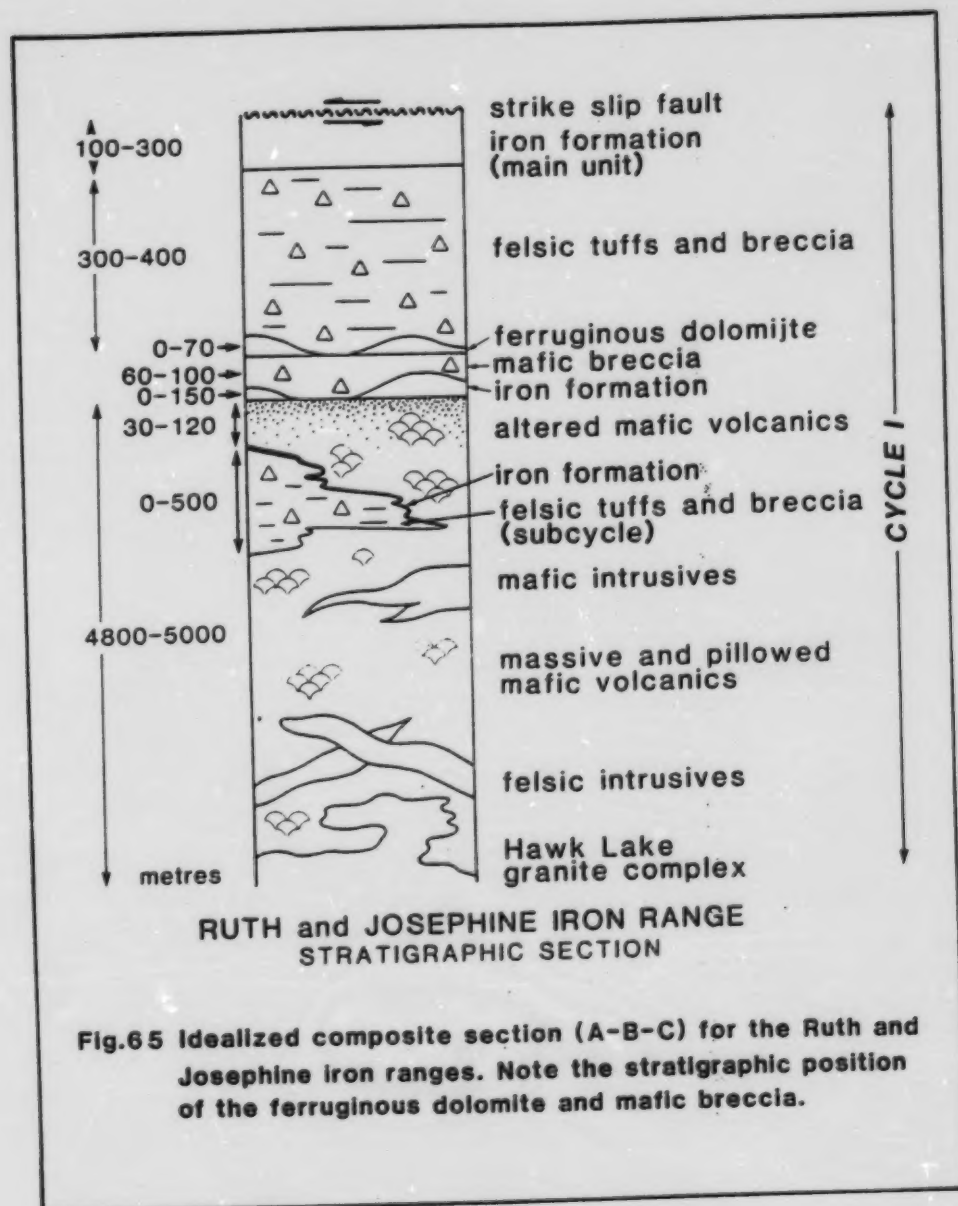
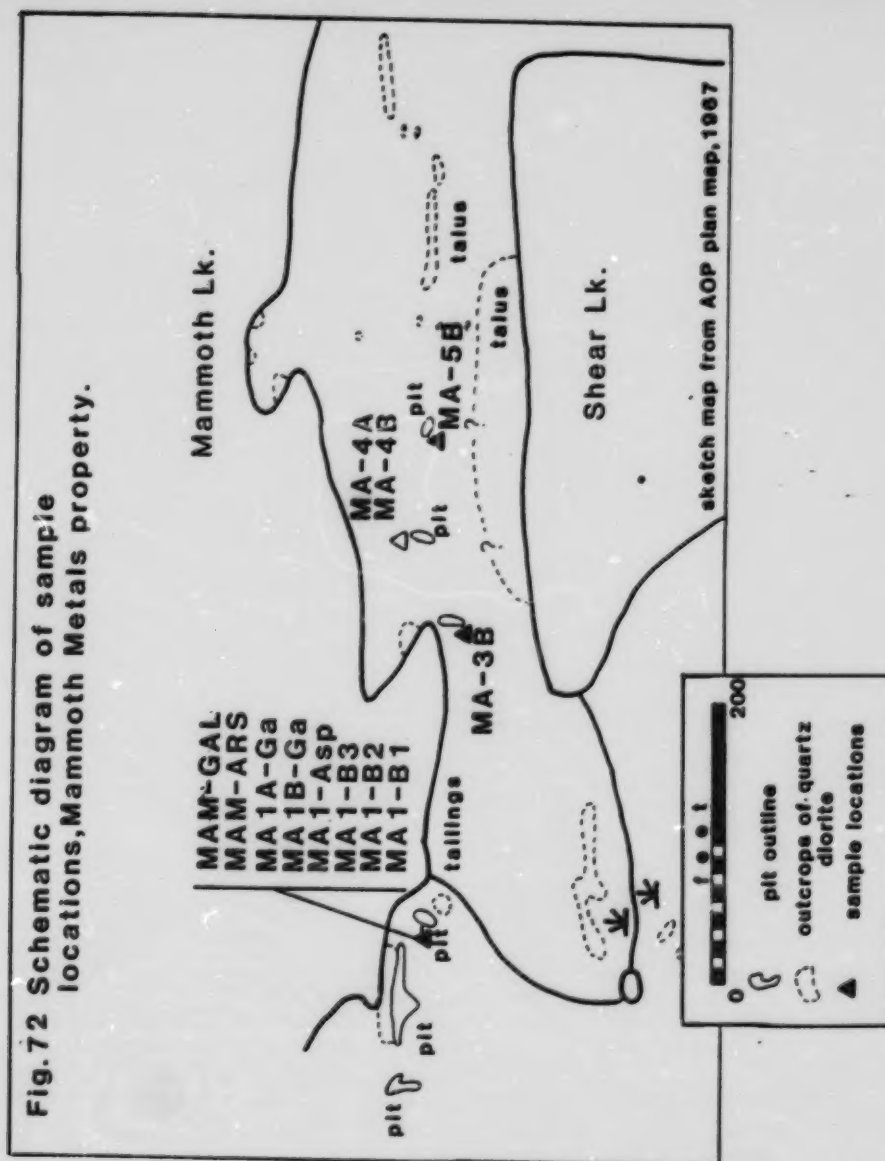
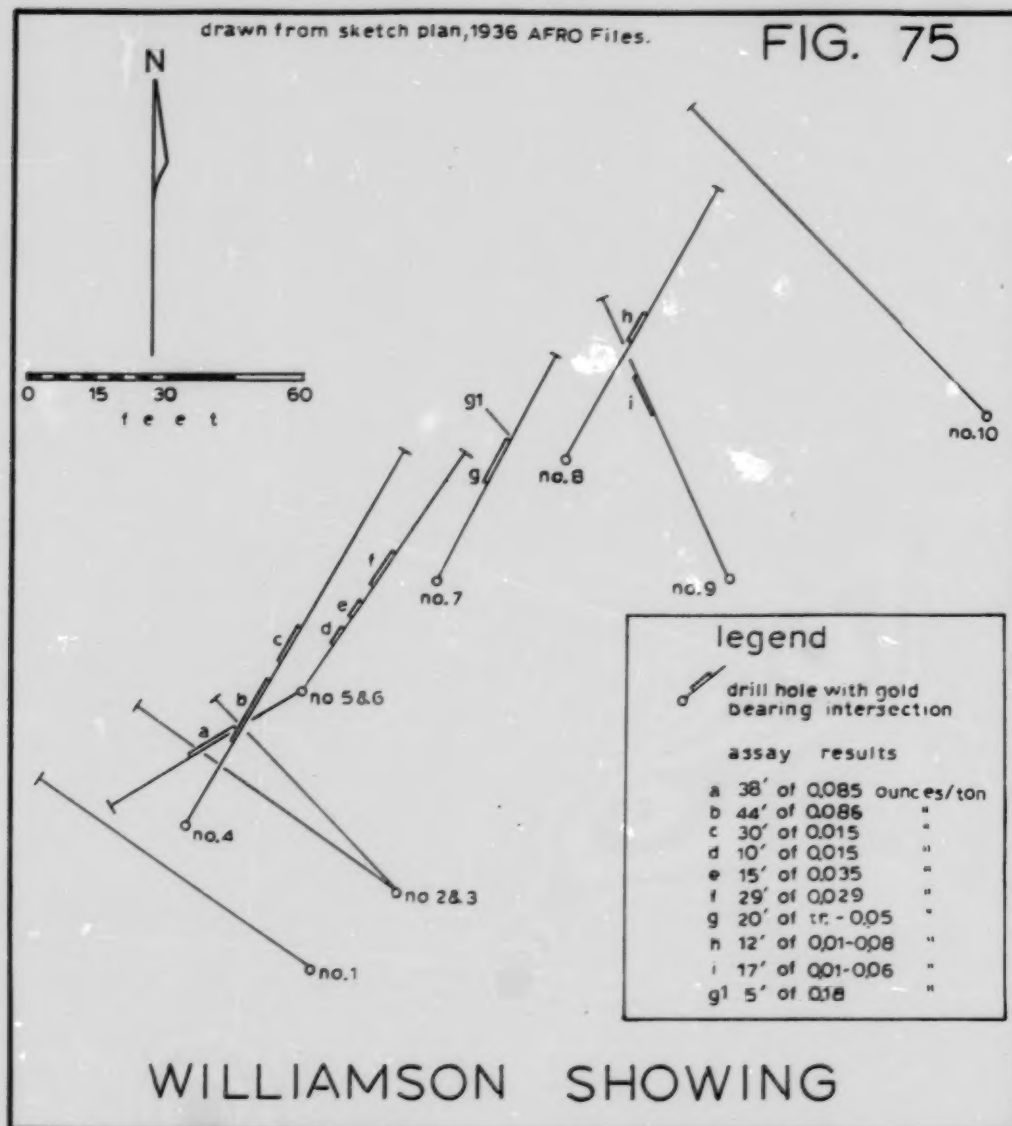


Fig. 72 Schematic diagram of sample locations, Mammoth Metals property.





ATNEL SHOWING

- LEGEND**
- Drill hole bearing/plunge
 - Shaft
 - Schistosity
 - 1 Sheared and carbonated diorite
 - 2 Quartz porph.

N

100'

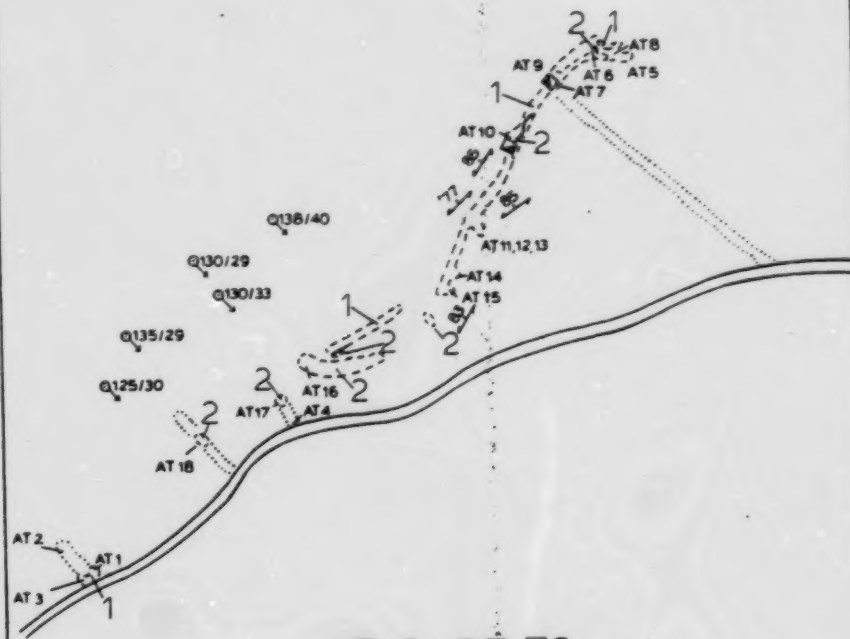


FIGURE 76

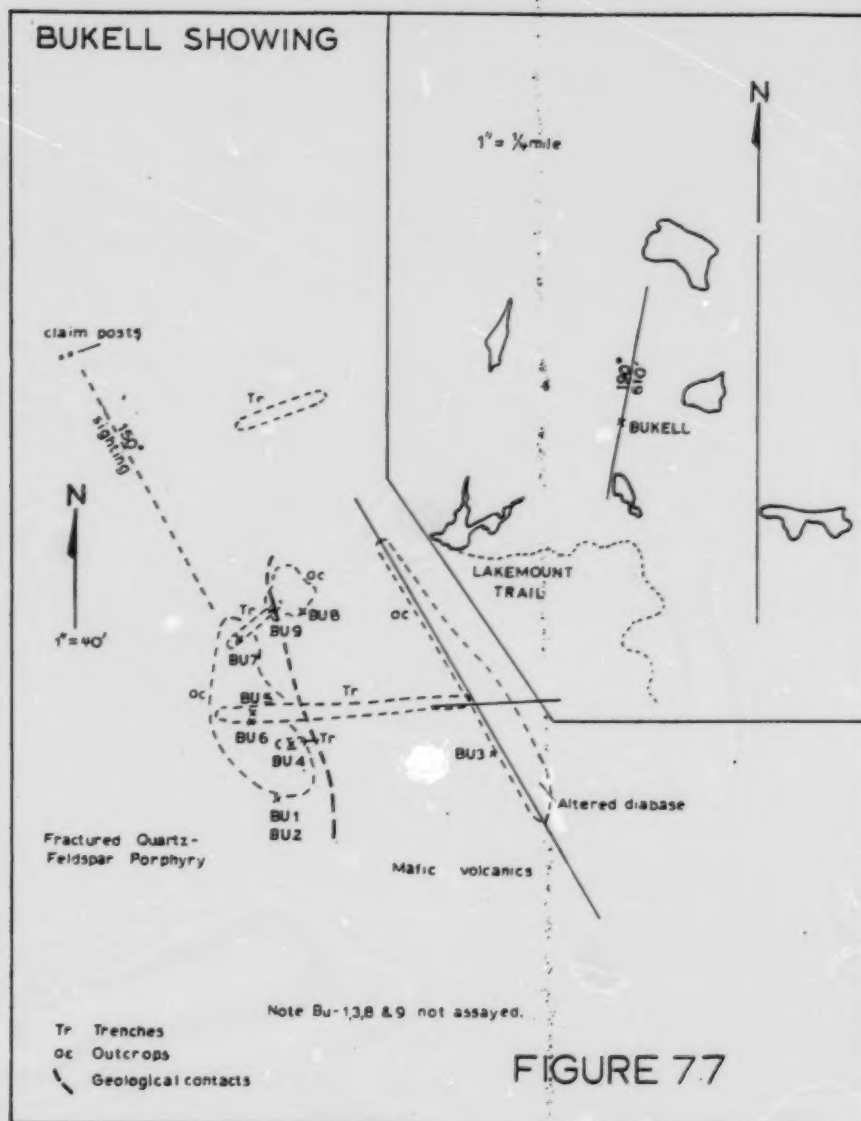


FIGURE 77

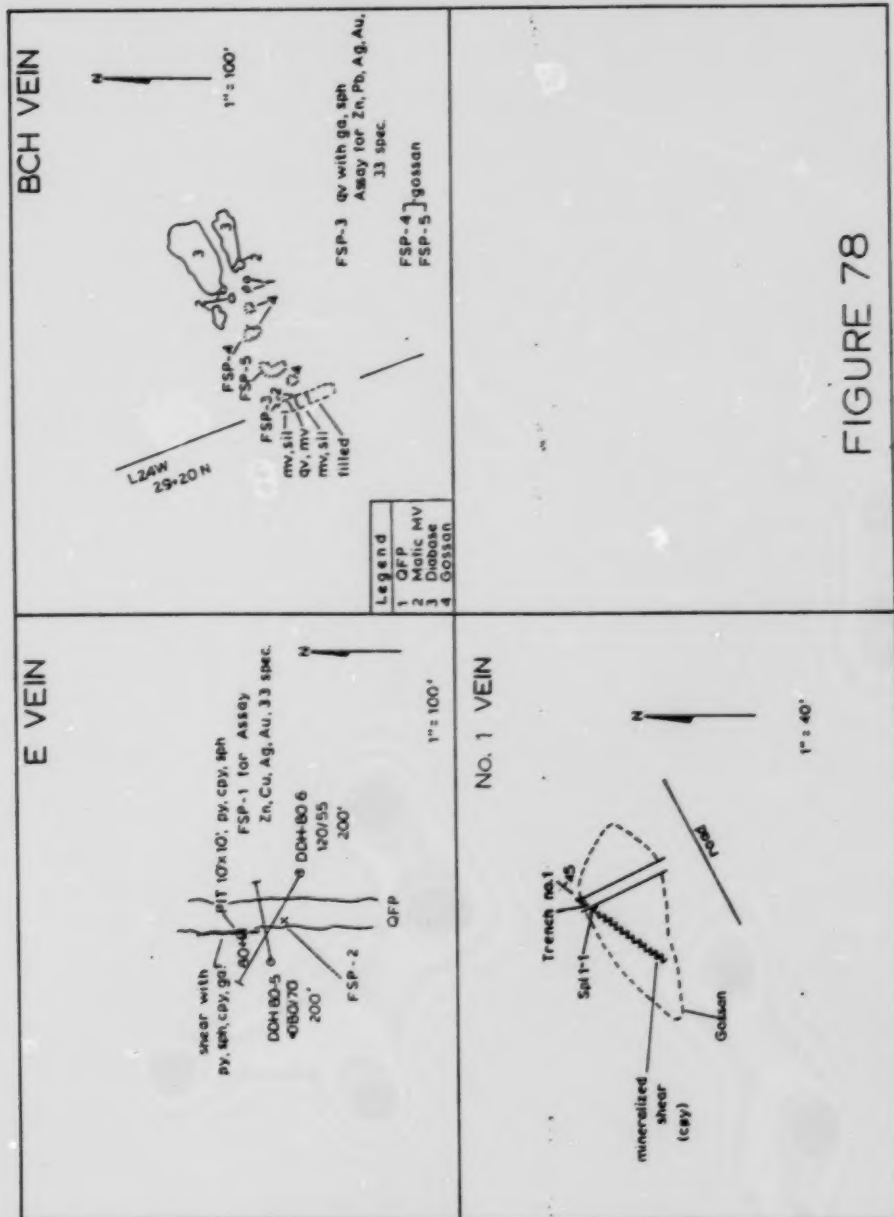


FIGURE 78

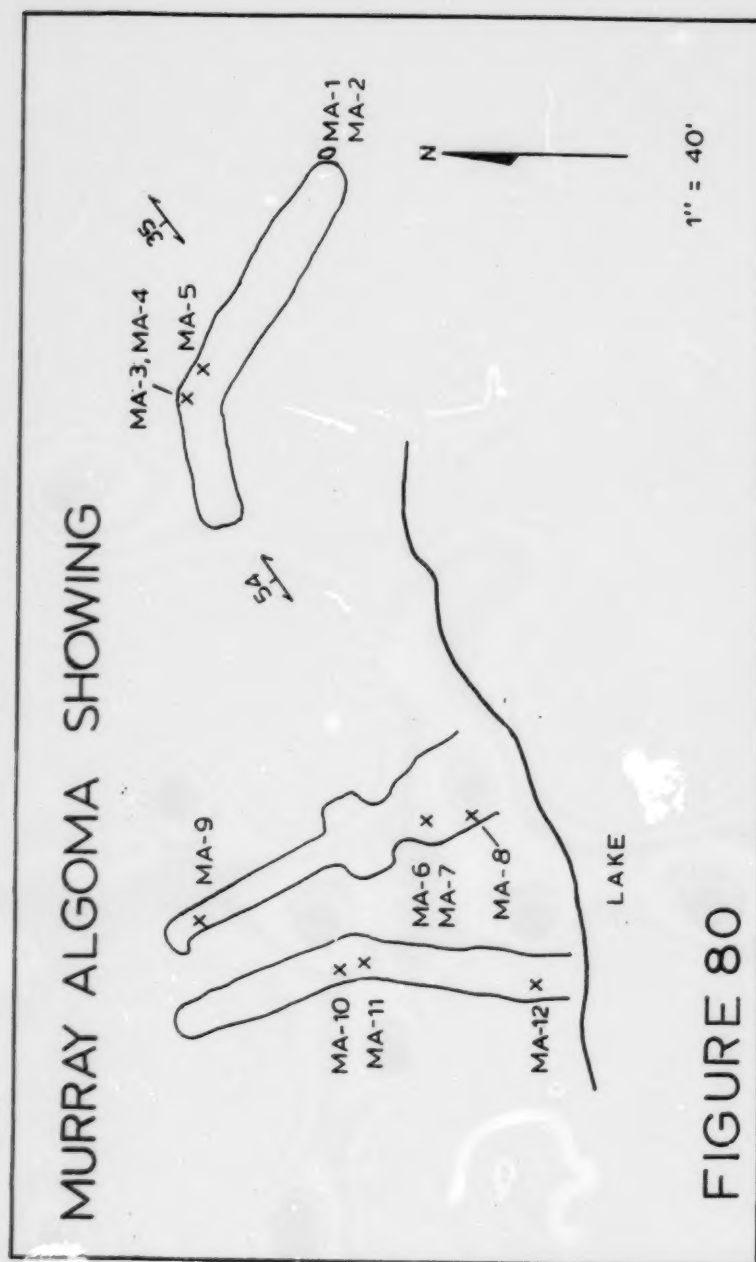
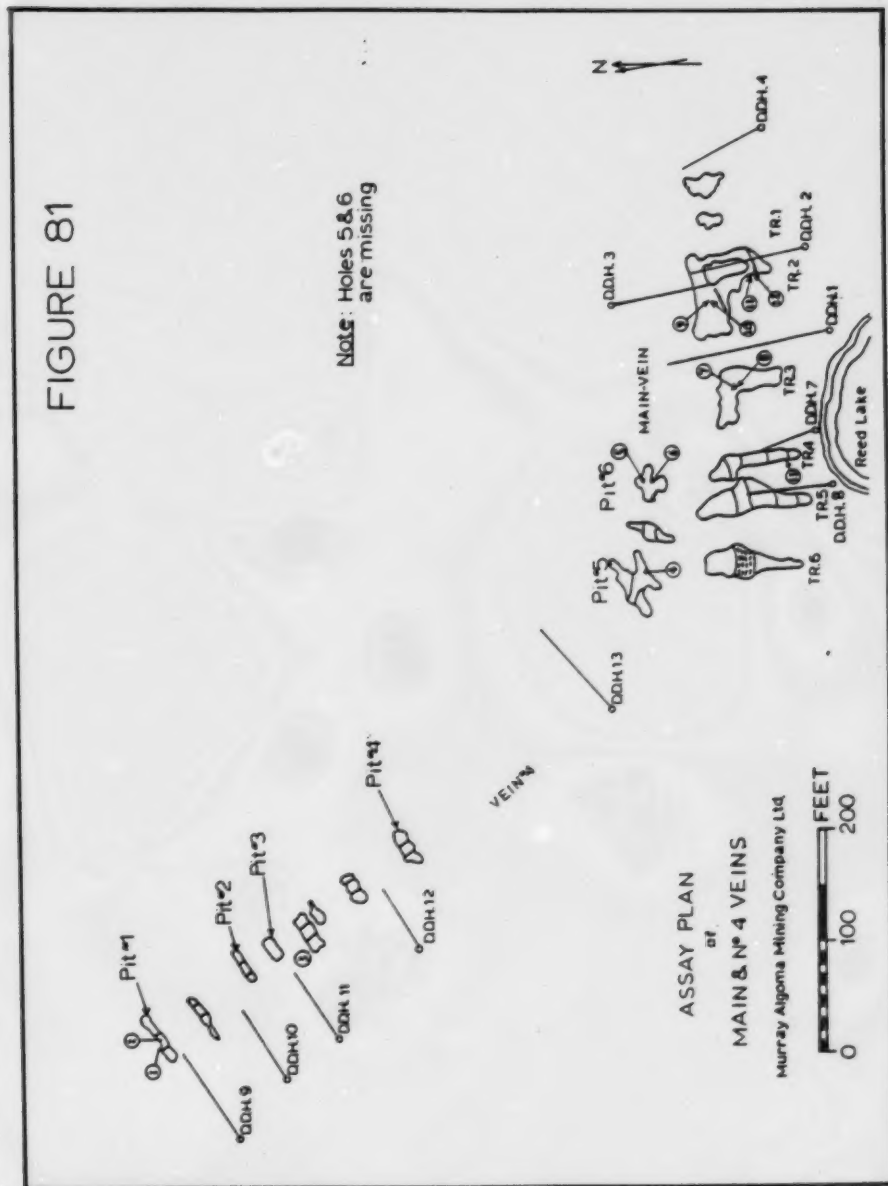


FIGURE 81

Note: Holes 5 & 6 are missing



SOOCANA-REED BOOTH SHOWING

GEOLOGY BY:
SYLVANITE GOLD
MINES LTD. (1940)

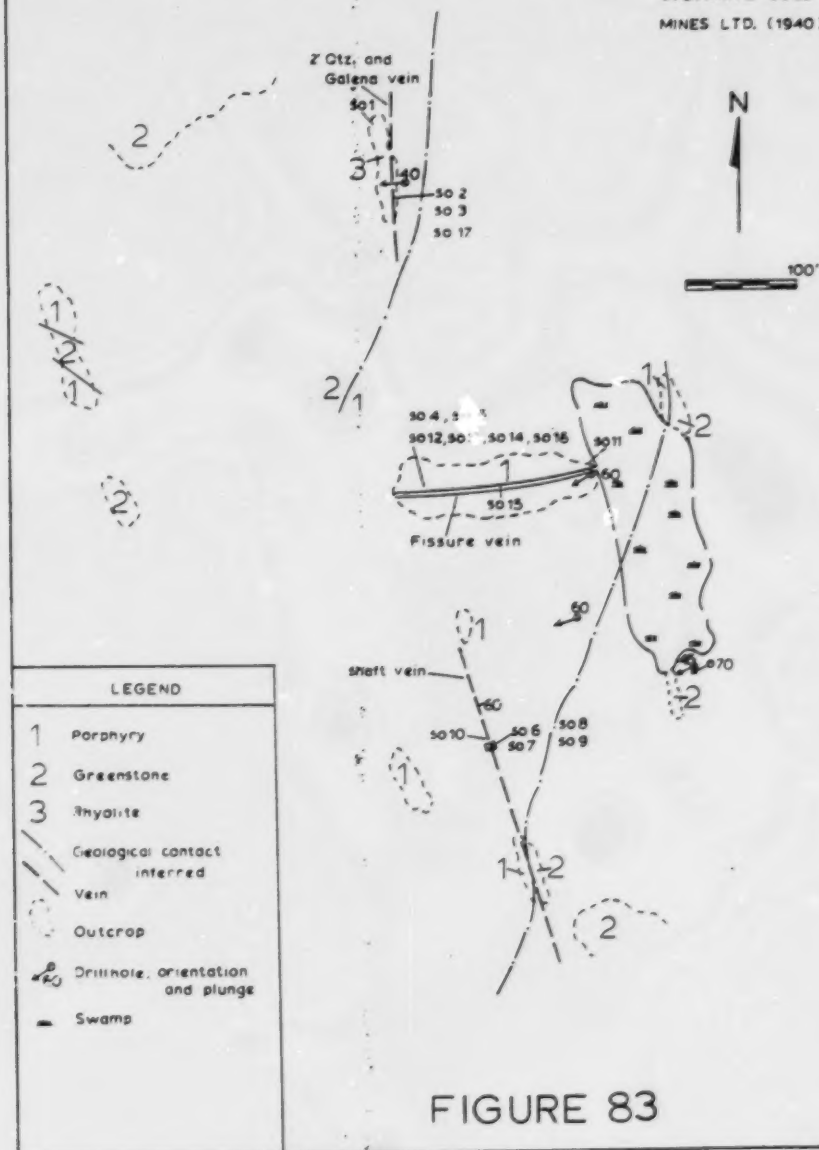


FIGURE 83

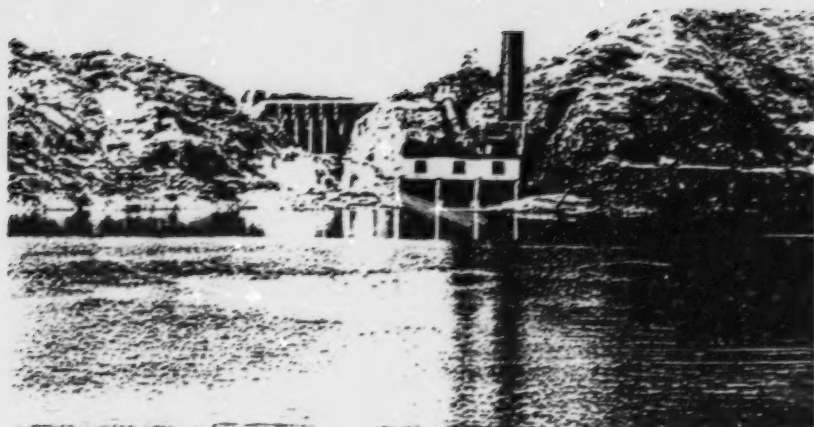
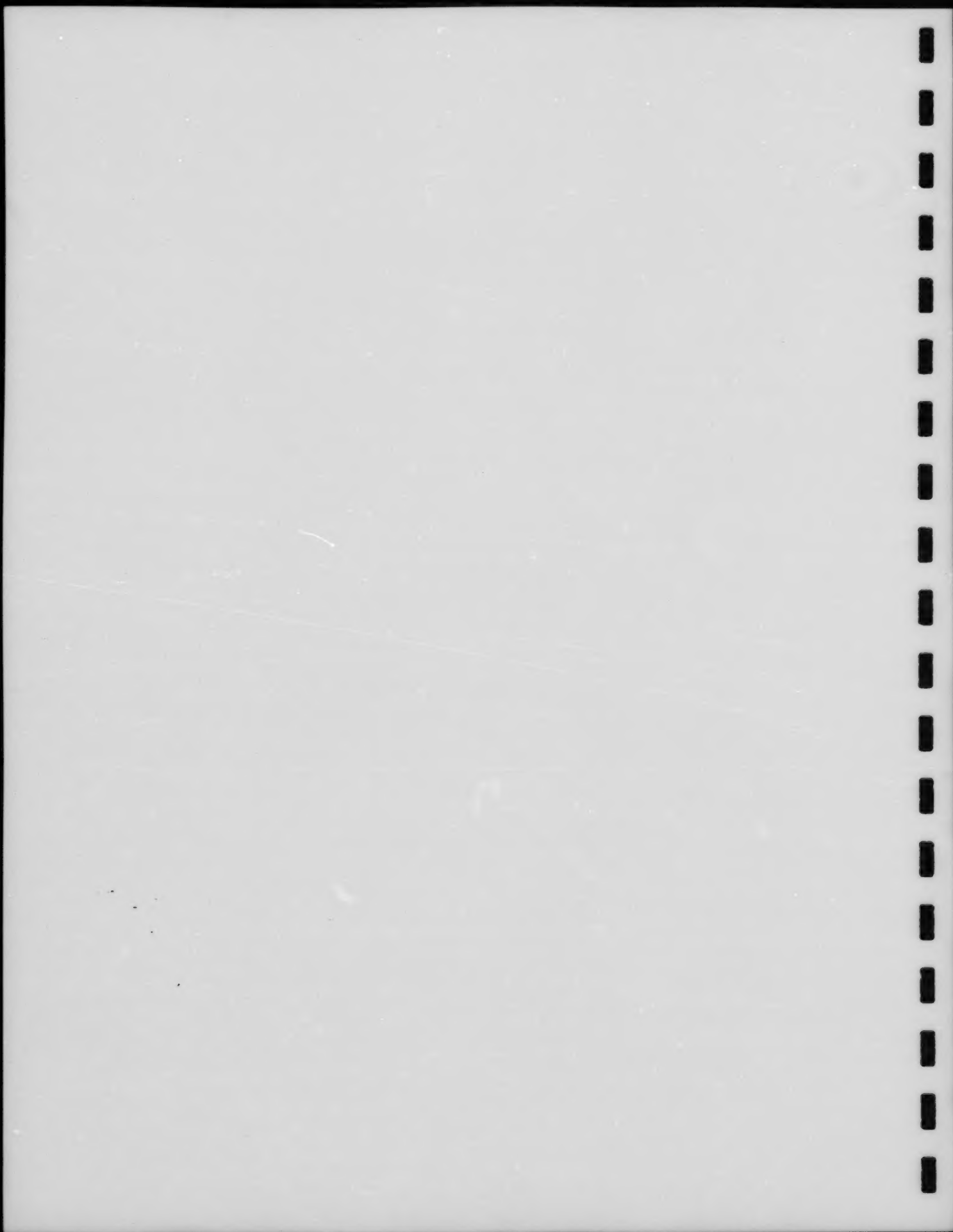


Photo 1. Abandoned dam and power house at Steep Hill Falls on the Magpie River. Photo taken in 1980.



Photo 2a. Treeless area north and west of McLeod shaft Helen Iron Range. Photo taken looking southeast. Top of headframe of MacLeod shaft on horizon.



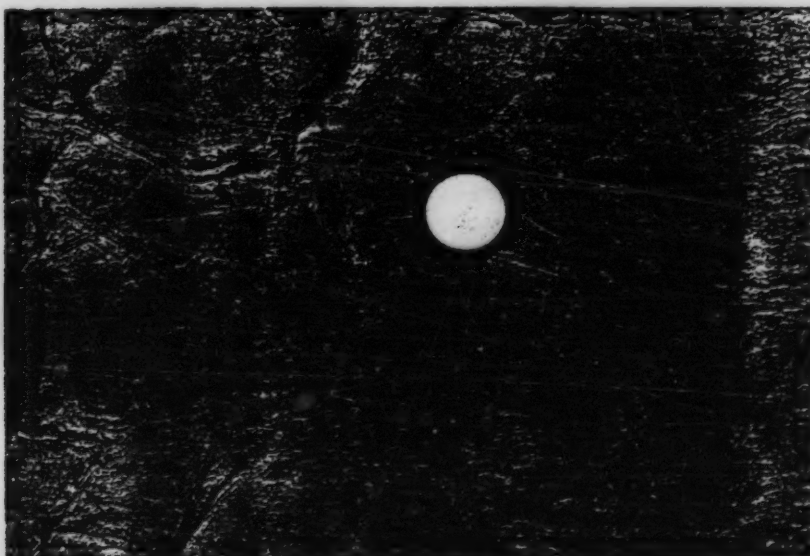


Photo 2b. Polysutured basaltic komatiite, Esquega Township. See sample 79-0072. Location P-34.

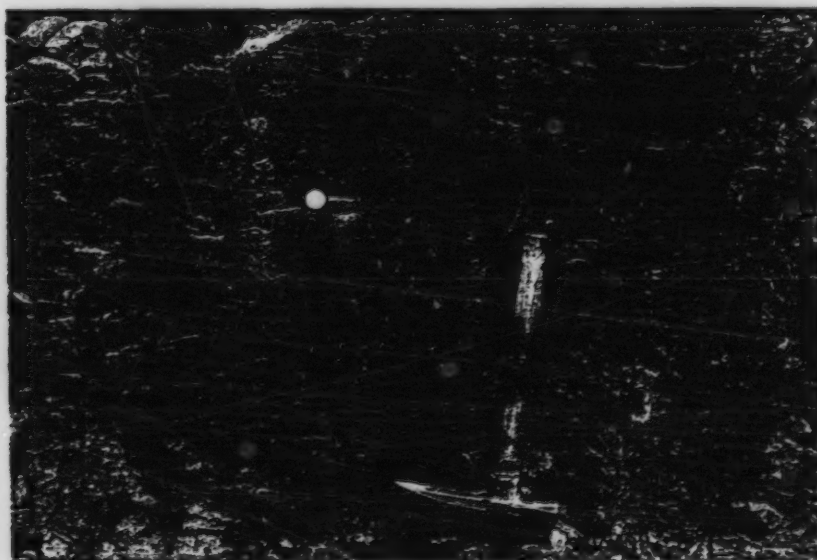


Photo 2c. Polysutured pillowed komatiite, Esquega Township. Location P-35.

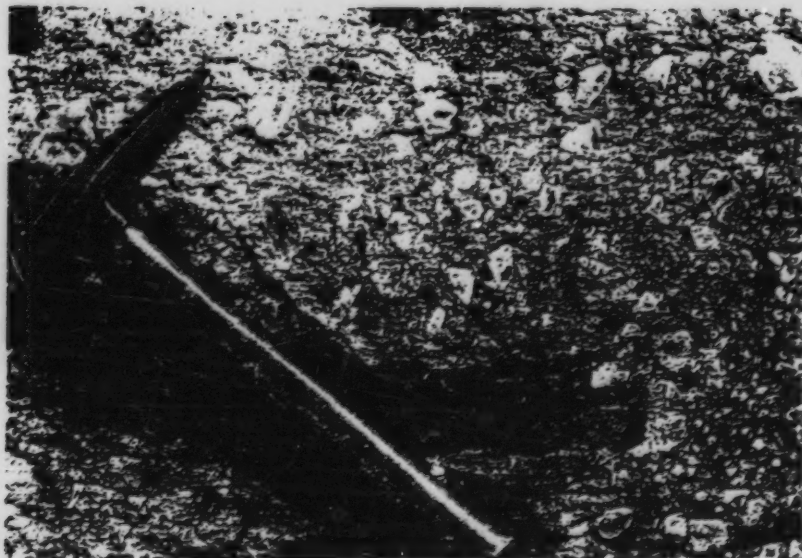


Photo 3. Coarse intermediate to felsic metavolcanic breccia northwest of the McLeod shaft and footwall to Helen Iron Range. Some clastic display a distinct bleaching of clast rims. Location P-1.



Photo 4. Polymictic breccia with clasts weathering in relief. South of Sunrise Lake, Esquega Township. Location P-2.

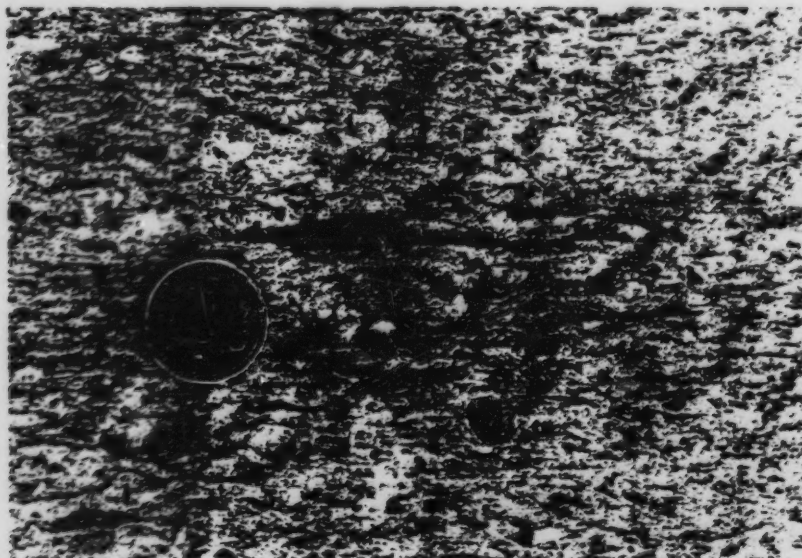


Photo 5. Possible fiamme in ash flow footwall to the Helen Iron Range. McMurray Township. Location P-3.



Photo 6. Thin bedded intermediate to felsic metavolcanic tuff east of sinter plant of Algoma Ore Properties Limited. McMurray Township, Location P-4.



Photo 7. Cross bedding in fine grained tuff of intermediate to felsic metavolcanic. McMurray Township, Location P-4.

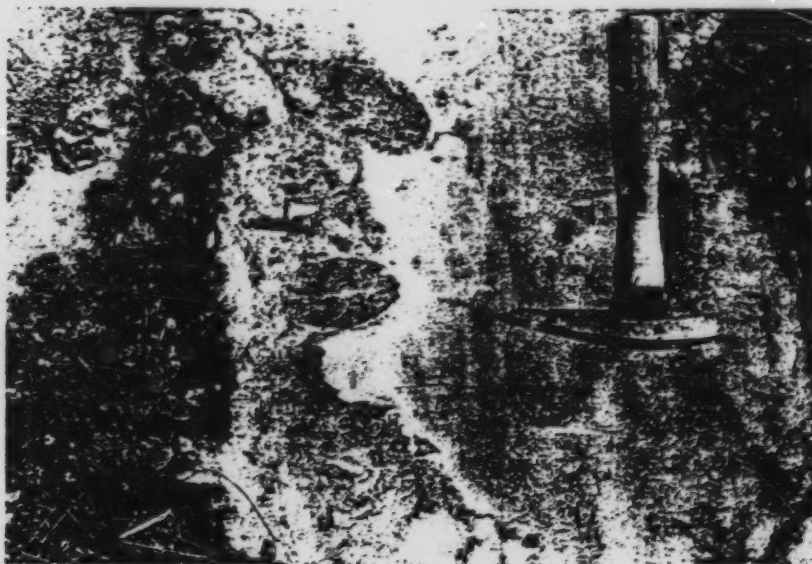


Photo 8. undulatory contact between fine grained tuff (top) and underlying lapilli tuff. Note draping of fine grained tuff over larger fragments. McMurray Township, Location P-4.

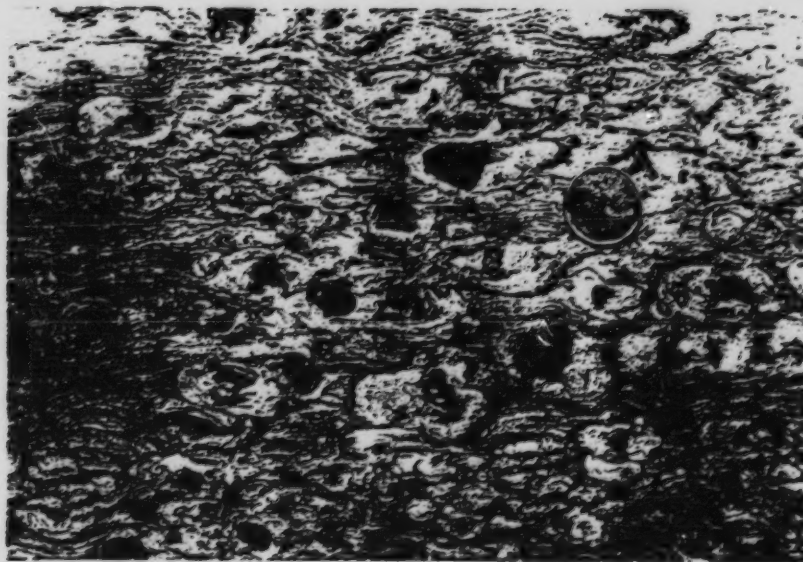


Photo 9. Hollow spherulites in felsic flow at west end of Wawa Lake. McMurray Township, Location P-5.



Photo 10. Coarse intermediate to felsic metavolcanic breccia of cycle two volcanism centered north of the Magpie River, Chabanel Township, Location P-6.

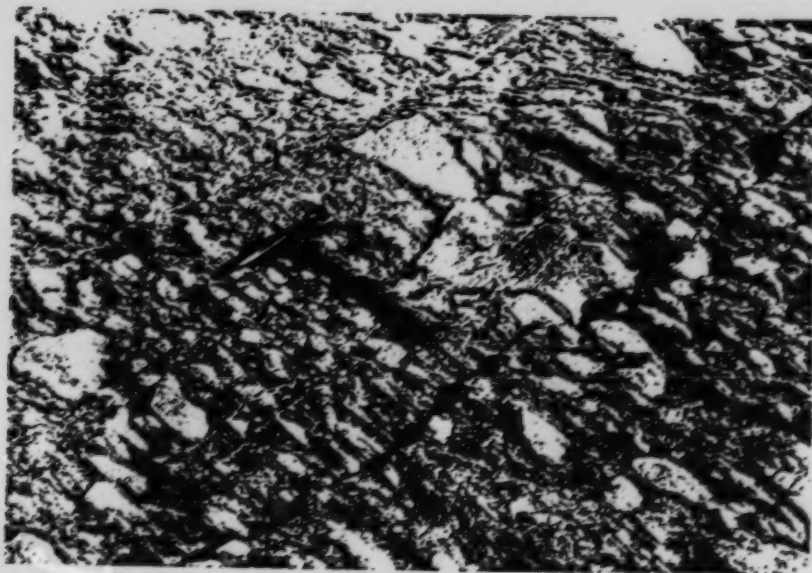


Photo 11. Coarse intermediate to felsic breccia north of abandoned power dam at Steep Hill Falls, Magpie River, Chabanel Township, Location P-7. Matrix of this breccia more chloritic than clasts.



Photo 12. Well bedded angular block of Jubilee tuff in granitic matrix of the Jubilee Stock. Intrusive breccia characterizes the east margin of the Jubilee Stock. Note lack of reaction rims or assimilation. Stanley Lake area, McMurray Township, Location P-8.



Photo 13. Subrounded to subangular clast of feldspar porphyry displaying good bleached reaction rim. Stanley Lake area, McMurray Township, Location P-9.

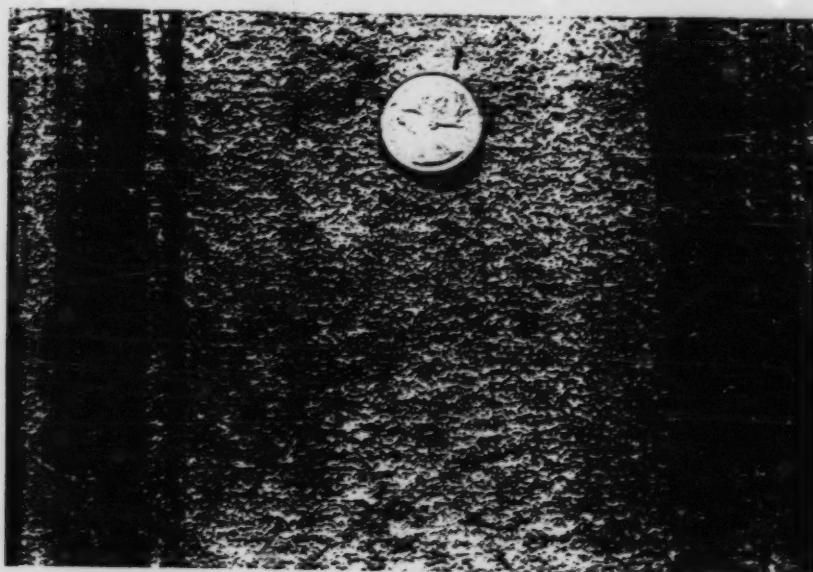


Photo 14. Graded bedding in wacke to subarkose bed between thin beds of siltstone to mudstone. Chabanel Township, Location P-10.

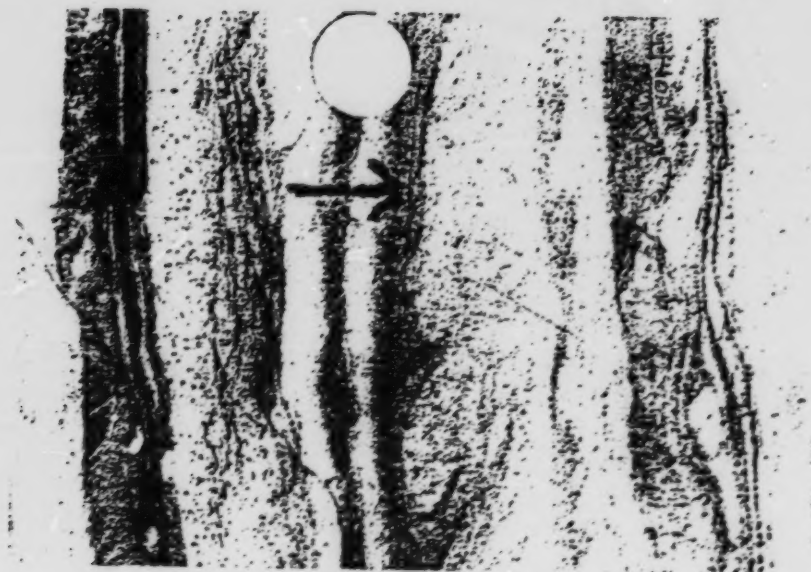


Photo 15. Flame structures, graded bedding, and soft sediment slump features. North of the Magpie River, Chabanel Township, Location P-11.



Photo 16. Flame structures in wacke displaying good grain gradations (not visible in photo). Flame structures indicate south facing stratigraphy in a north dipping sequence. Chabanel Township, Location P-12.



Photo 17. Graded bedding and soft sediment slump structures, Steep Hill Falls area, Chabanel Township, Location P-13.

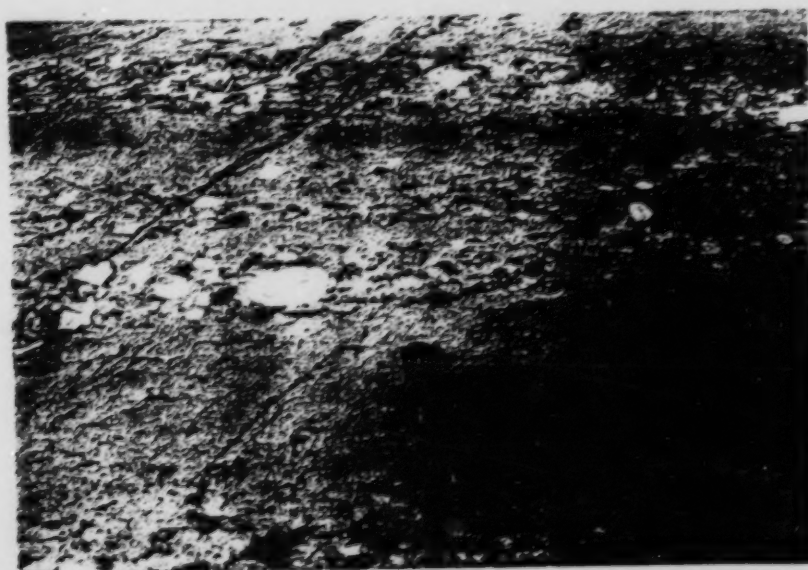


Photo 18. Chert pebble conglomerate near base of sedimentary section above Lucy Iron Range. Chert varies from massive to finely laminated and from subangular to rounded, Chabanel Township, Location P-14.



Photo 19. Drap structures over rounded laminated chert cobbles in chert pebble conglomerate near base of section above Lucy Iron Range, Chabanel Township, Location P-15.

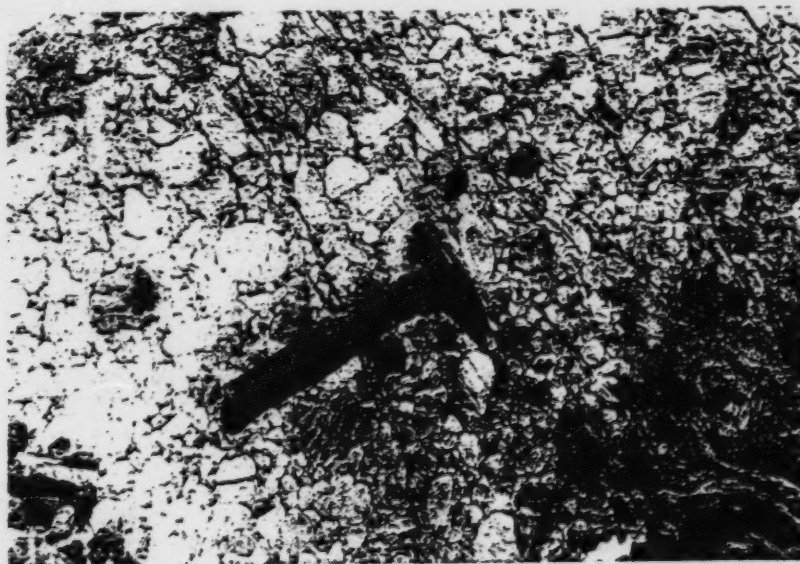


Photo 20. Clast supported chert pebble conglomerate near base of metasedimentary section above Lucy Iron Range. Note subrounded to subangular shape of clasts, Chabanel Township, Location P-16.

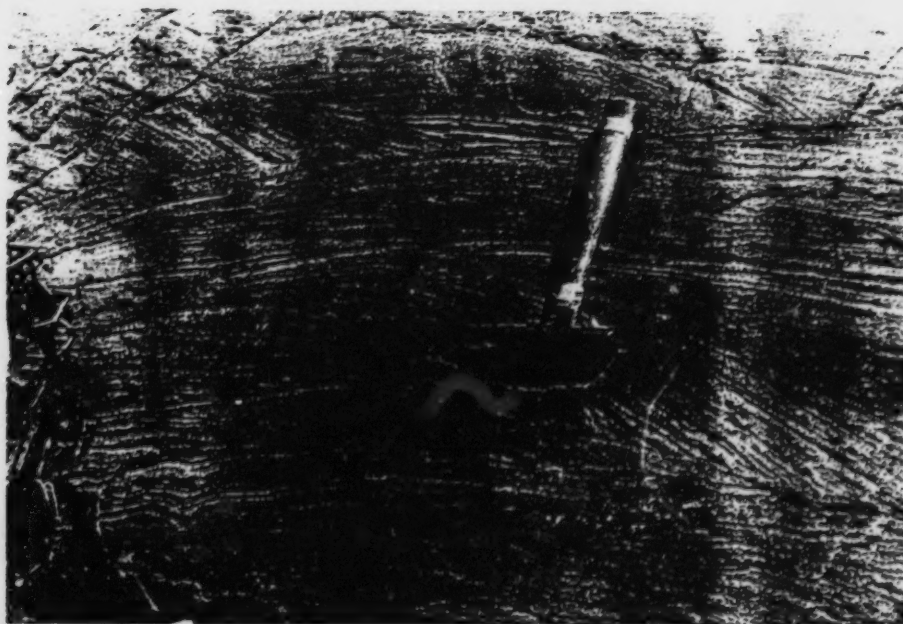


Photo 21. Excellent trough cross bedding in metasedimentary rocks above Lucy Iron Range. Esquega Township, Location P-17.



Photo 22. Soft sediment slump structures in metasedimentary rocks above Lucy Iron Range, Chabanel Township, Location P-18.

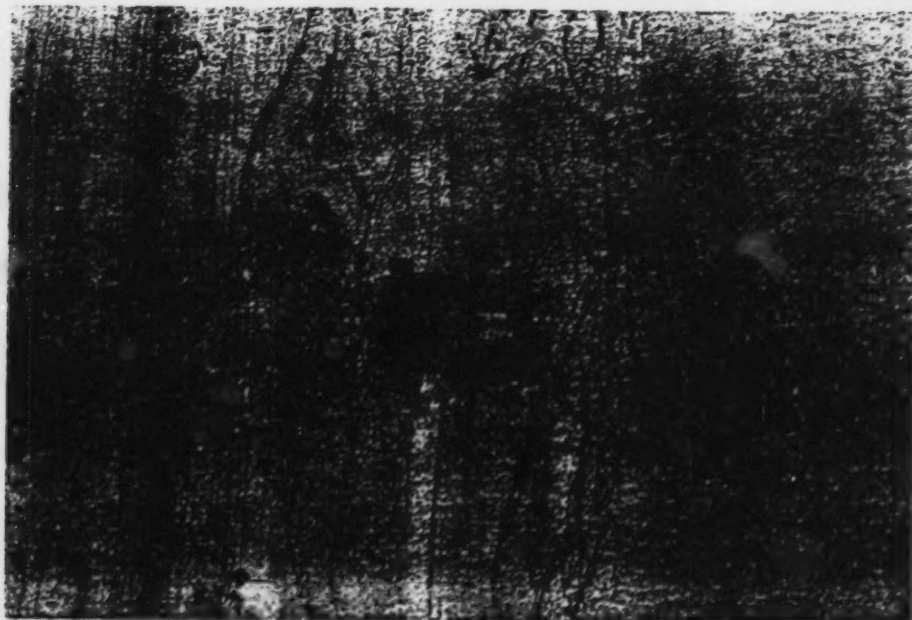


Photo 23. End of view of climbing ripples in metasedimentary rocks above Lucy Iron Range, Chabanel Township, Location P-19.

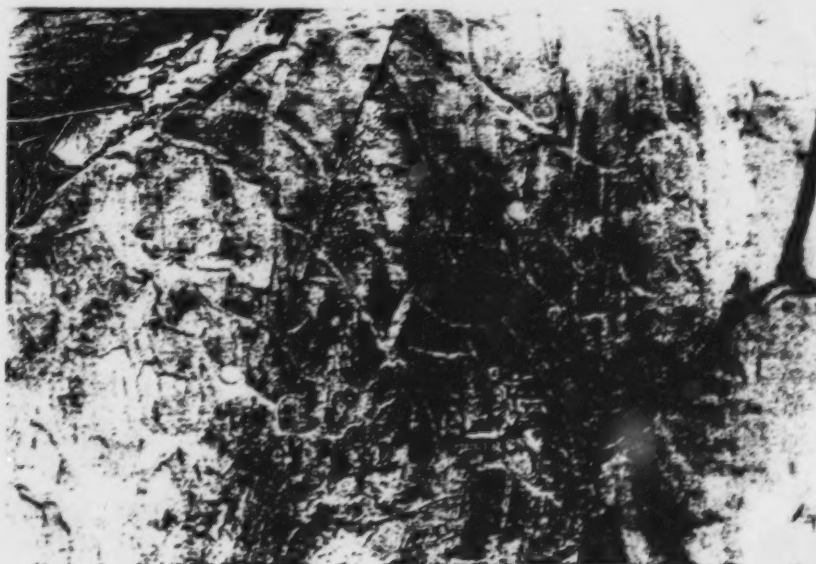


Photo 24. Desiccation cracks in metasedimentary rocks above Lucy Iron Range, Esquega Township, Location P-20.



Photo 25. Ripple marks on numerous bedding surfaces in wacke metasedimentary rocks north of Mildred Lake, Chabanel Township, Location P-21.

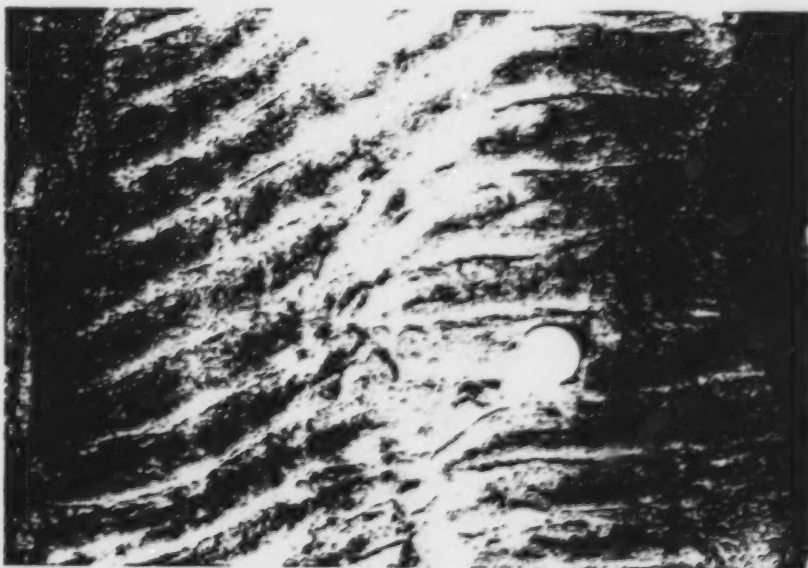


Photo 26. Close up of ripple marks on one bedding surface in wacke metasedimentary rocks north of Mildred Lake. See Plate 25 for view of outcrop. Location P-21.



Photo 27. Ripple marks in wacke metasedimentary rocks at the north end of Bauldry Lake, Esquega Township, Location P-22.

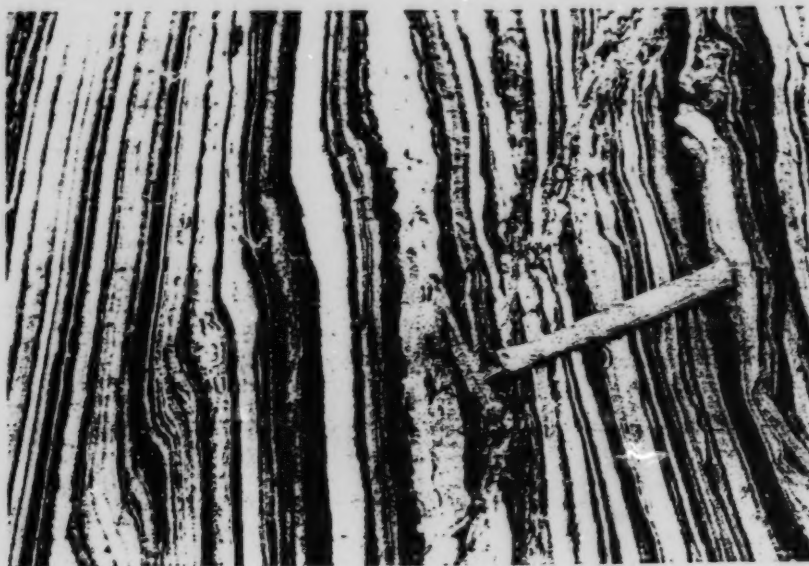


Photo 28. Thin bedded chert-wacke-magnetite in upper portion of Helen Iron Range. Chabanel Township, Location P-23.



Photo 29. Upper contact of Eleanor Iron Range with base of overlying mafic flow of cycle two volcanic rocks. Contact of argillite-pyrite facies of iron formation immediately to left of person in photo. Chabanel Township, Location P-24.



Photo 30. Interbedded chert-wacke iron formation in the upper part of Lucy Iron Range. Chabanel Township, Location P-25. Note the alteration of brecciated and unbrecciated iron formation.

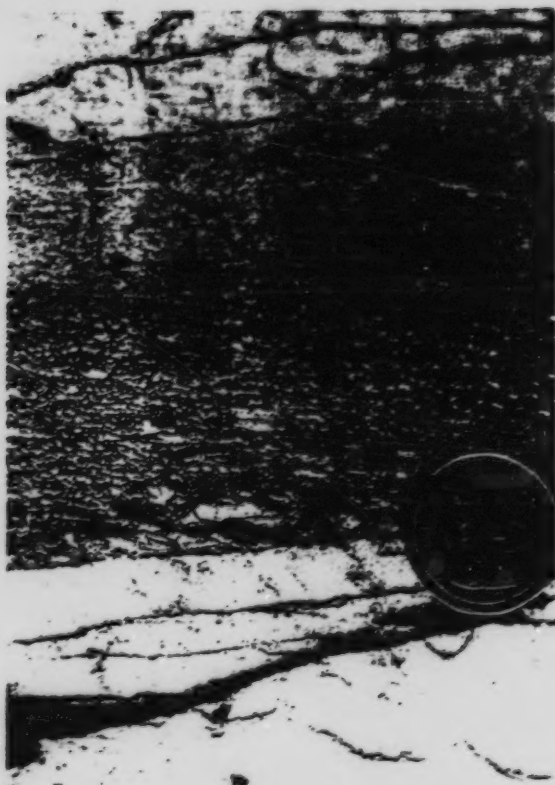


Photo 31



Photo 32

Photo 31. Close up of one wacke bed in chert-wacke facies of iron formation of the Lucy Iron Range. Same site as Plate 30. Note grain gradation within tuff forming wacke bed, Chabanel Township, Location P-25. Tops are north on grain gradation consistent with topping directions based on pillows within intermediate to mafic metavolcanic rocks directly above iron range.

Photo 32. Grading of fragment size in lapilli tuffs immediately below Helen Iron Range. Cement to the tuff is siderite. Chabanel Township, Location P-26.

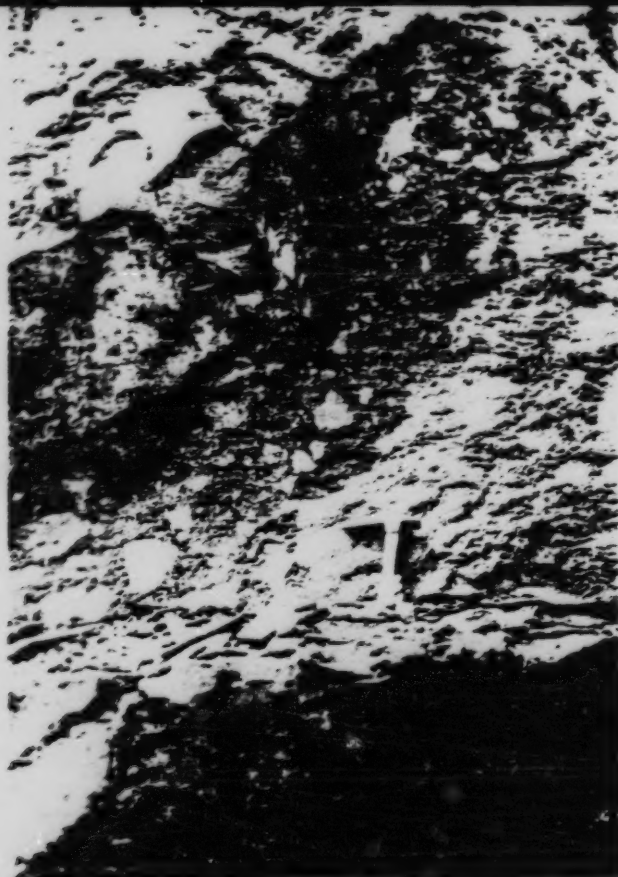


Photo 33. Hydroexplosion breccia below the Lucy Iron Range. Breccia is cemented with siderite. Chabanel Township, Location P-27.

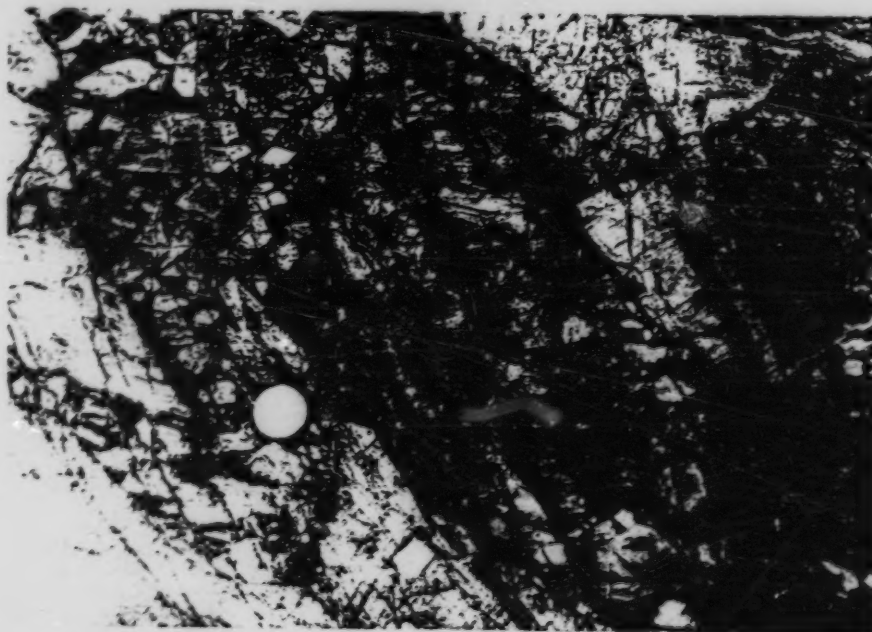


Photo 34. Hydroexplosion breccia below Helen Iron Range. Breccia cemented with siderite. Chabanel Township, Location P-28.

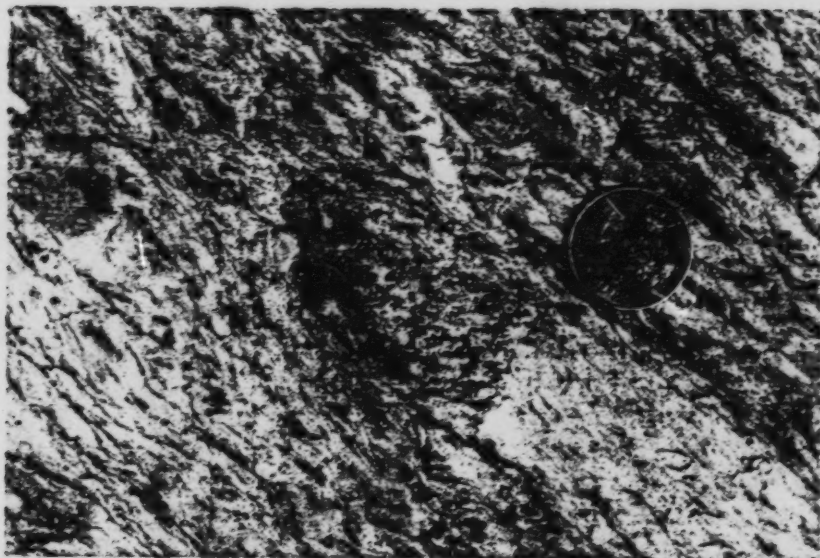


Photo 35. Chloritoid selectively replacing clasts in preference to matrix. Chabanel Township, Location P-29. Alteration of clast may precede incorporation in tuff.



Photo 36. Chloritoid occurring along fractures. These fractures were probably cooling cracks that permitted access of hydrothermal fluids. Chabanel Township, Location P-30.

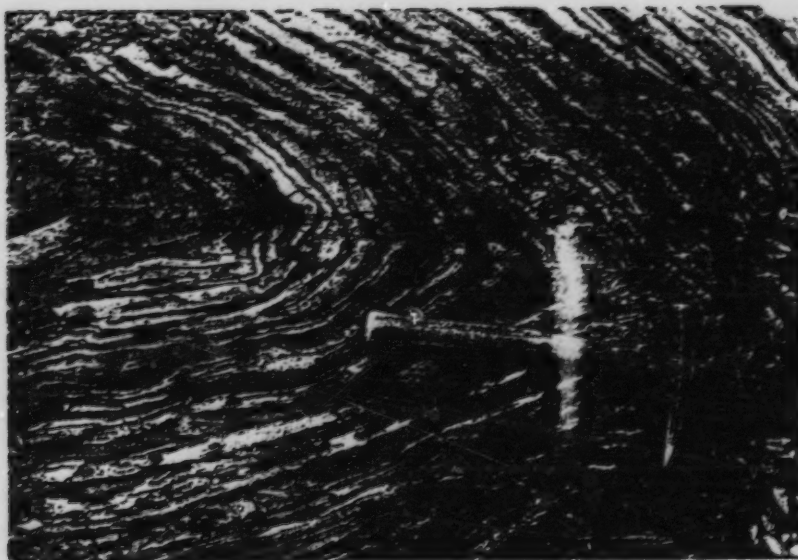


Photo 37. Tight folding in chert-wacke-magnetite iron formation at the west end of the Helen Iron Range, Chabanel Township, Location P-31.



Photo 38. North facing pillows in first flow above Eleanor Iron Range. This is the base of cycle two volcanism. Chabanel Township, Location P-32.



Photo 39. Top of shaft on Soocana Reed-Booth Gold Showing, Esquega Township.

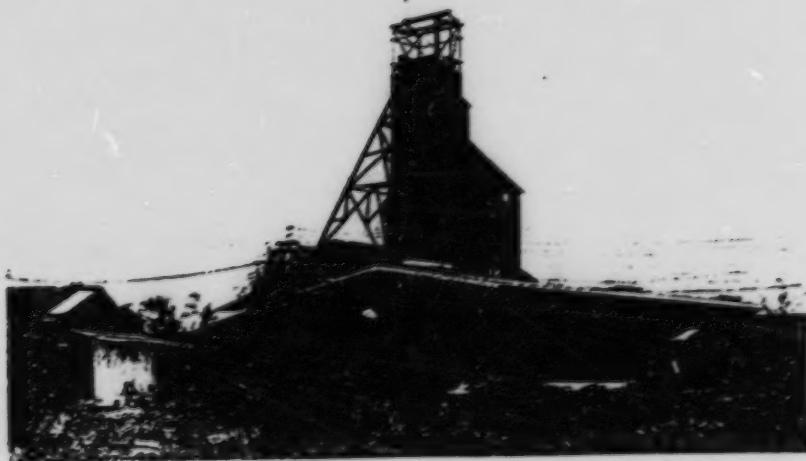


Photo 40. Surface buildings of Citadel Gold Mines Incorporated. McMurray Township.



Photo 41. Reworked tuffs along south side of Parkhill Vein. Small scours and flame structures present in addition to well developed grain gradations. McMurray Township, Location P-33.



Photo 42. Steele frame above vertical shaft on Darwin property of Dunraine Mines Limited. Photo taken in 1985.

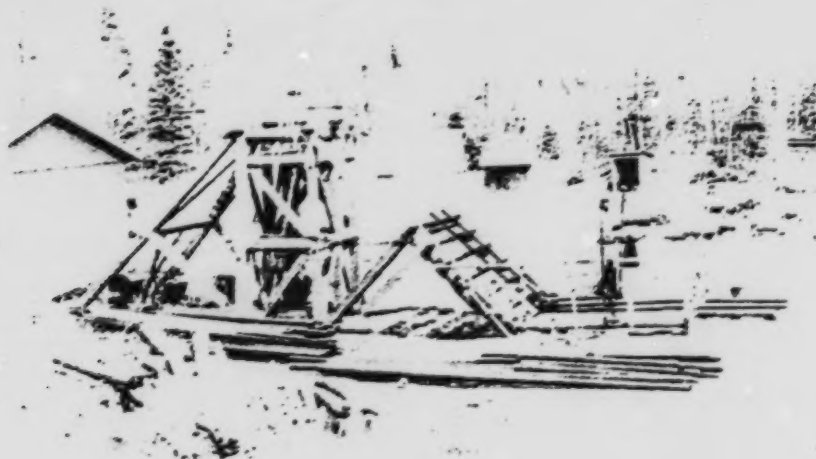


Photo 43. Exploration and testing of old workings of former Parkhill mine by Dunraine Mines Limited. The exploration headframe is as in appeared in 1985.

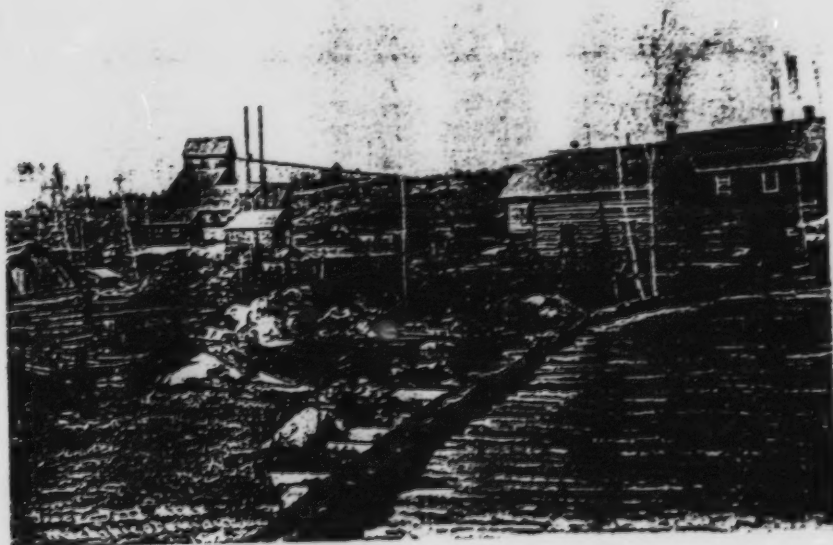


Photo 44. Darwin property as it appeared in 1908 and known as the Grace Gold Mine, photo from Wawa Chamber of Commerce.

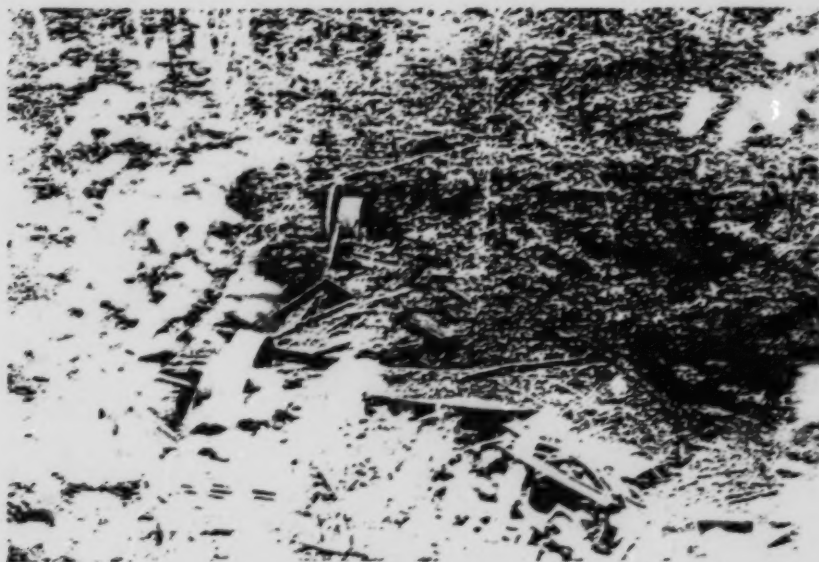


Photo 45. Equipment remaining at the site of the Golden Reed Gold Mines Limited. Photo taken in 1980.



Photo 46. Golden Reed Gold Mines Limited as it appeared in 1908, photo from Wawa Chamber of Commerce.

DESCRIPTION OF PROPERTIES

Exploration activity in the Wawa area has been intense since the turn of the century. An extensive volume of data has accumulated. The reader should refer to the Assessment Files Research Office, Toronto for details.

In regards to those properties concerned with iron formation, the reader should refer to the geological section of this report as their geology is essentially identical for each property. Descriptions of properties is by township and the emphasis is on exploration history and development. The locations of all properties discussed are indicated on the accompanying maps.

In discussion of the individual iron ranges, reference will not necessarily be made to earlier work. For those interested in additional information and previous interpretations they should refer to the reports by Parsons (1915), Collins and Quirke (1926) and Moore and Armstrong (1946). Previous articles dealing with Michipicoten Iron Formation are extensively referenced in that section of the report dealing with iron formation.

CHABANEL TOWNSHIP

ALGOMA ORE PROPERTIES (1)

Algoma Ore Properties, a division of Algoma Steel Corporation Limited has been active in mineral exploration in the Wawa area for many years. The work completed by this company on the various iron ranges will be discussed under the respective iron ranges. The company has at various times conducted exploration for other minerals in the area. As recently as 1981, the company completed an exploration program in search of base metals. The work by this company will be subdivided into a number of subheadings and discussed individually.

ASSESSMENT DRILL HOLE A-1 (1-A)

The company completed a deep diamond drill hole of 1453 feet on claim 23021 north of Wawa Lake in 1952. The hole failed to encounter mineralization of interest. The drill log indicates the drill intersected intermediate to felsic metavolcanic rocks and thin units of black slate (AFRO). Mapping in the area of the drilling indicates an intermediate to mafic metavolcanic stratigraphy.

ASSESSMENT DRILL HOLE A-2 (1-B)

The company completed a deep diamond drill hole totaling 1448 feet on claim 23877 in 1953. This hole failed to find mineralization of interest. The drill log indicates the hole intersected tuff and quartz porphyry (AFRO).

ASSESSMENT DRILL HOLE A-4 (1-C)

The company completed a deep diamond drill hole totaling 2441 feet on

claim 22728 on the north shore of Arliss Lake in 1953. This hole failed to encounter mineralization. The drill log indicates the hole penetrated metasedimentary rocks and metagabbro (AFRO).

ASSESSMENT DRILL HOLE A-5 (1-D)

The company completed a deep diamond drill hole totaling 2044 feet on claim 21169 north of Lena Lake in 1953. One foot of wacke containing arsenopyrite was encountered at a depth of 2038 feet. Assays were not reported. The drill log indicates a metasedimentary and metagabbro lithology (AFRO).

ASSESSMENT DRILL HOLE A-8 (1-E)

The company completed one short diamond drill hole of 160 feet in the intermediate to felsic metavolcanic rocks north of Wawa Lake in 1953. The hole was on claim 23022 and failed to encounter mineralization. The drill log indicates intermediate to felsic metavolcanic rocks and metagabbro were penetrated by the drill (AFRO).

EAST OF BROOKS LAKE (1-F)

The company completed 3 short diamond drill holes from the same site on claim 88561. The drilling totalled 281.0 feet. The purpose of the drilling is uncertain and no mineralization was encountered. The drill logs indicate intermediate to mafic metavolcanic rocks were encountered.

ELEANOR (LENA)-ARLISS LAKES AREA (1-G)

The company completed a geological report on the area between Eleanor (Lena) Lake and the Magpie River to the west (Metcalf 1952). Follow up work was not reported.

LENA LAKE (1-H)

The presence of asbestos in an ultramafic intrusion at Lena Lake was first recognized by Collins and Quirke (1926, p.131). The site was relocated by Giblin (1972) who recommended additional work. The aeromagnetic anomaly over this intrusion is known as Wagner's anomaly 13 (Macauley 1962a). Khan (1972) examined the occurrence and considered it not to be of economic interest. The occurrence is on the west end of the most westerly of three islands in the south central part of Lena Lake. Khan (1972, p.2) described the occurrence as veinlets and patches of asbestos fibre 1/8 inch to 1/4 inch wide. The veinlets vary from 2 to 4 feet long and comprise less than 1% of the rock (Khan 1972). The asbestos was described (Khan 1972) as pale green in colour and brittle.

The reported asbestos is probably chrysotile and since it composes less than 1% of the rock it would not likely be commercial, even if of good quality. The intrusion appears reasonably fresh in thin section. While serpentine is present in thin sections, studied one would expect a much greater degree of serpentinization if asbestos was present in quantity.

The Lena Lake peridotite is interpreted by the author to be much younger than the Sunrise Lake peridotite that hosts copper, nickel and platinum group element mineralization. No evidence of sulphide mineralization was observed by the field party nor has sulphide mineralization been reported from the Lena Lake intrusion by Giblin (1972) or Khan (1972).

The company also examined the Lena Lake peridotite unsuccessfully for vermiculite.

In 1964 the company completed one diamond drill hole from the surface of Lena Lake totaling 415 feet. The hole is reported to have encountered metasedimentary rocks and between 205 and 245 feet the drill log reports the presence of graphite and pyrite. Samples from the core were examined by spectrographic analysis by the company without finding anything of interest.

MICHIPICOTEN BASE METALS PROJECT (1-I)

From 1980 to 1982, Algoma Ore Properties completed geological surveys and airborne magnetic and electromagnetic surveys in the Wawa area. Grids were cut on a number of airborne indicated anomalies. The discussion will be restricted to those anomalies that were drill tested.

ANOMALY 17C (1I1)

The company completed one diamond drill hole (MB-2-81) totaling 453 feet on an airborne indicated anomaly southeast of the Lucy Iron Range close to the border between Chabanel Township and Esquega Township in 1981. This hole encountered 20 to 50% banded pyrite with 2% pyrrhotite

from 369.5 to 373.0 feet. Assay data for Au, Ag, Cu and Zn reported by the company indicated nothing of economic interest. The best values are; 0.01 oz Au per ton from 371.0 to 372.0 feet, 0.09 oz Ag per ton from 409.5 to 410.0 feet, 0.313% Cu from 435.0 to 435.5 feet and 0.0780% Zn from 435.0 to 535.5 feet (AFRO, Toronto).

ANOMALY 11B (1I2)

The company completed one diamond drill hole (MB-3-81) totaling 311.5 feet on an anomaly north of Pointer Lake (local name) in 1981. The drill log indicates between 5 and 15% pyrrhotite in association with chert and laminated graphitic schist between 272.0 and 283.7 feet. Assays reported by the company indicate all Au values as less than 0.001 ounces per ton and all Ag values were 0.02 ounces per ton or less. The maximum Cu value was 3130 ppm and the maximum Zn value was 780 ppm (AFRO, Toronto).

ANOMALY 15 (1I3)

The company completed one diamond drill hole (MB-14-81) totaling 82.5 feet on an anomaly in the centre of Chabanel Township in 1981. Between 49.25 and 53.6 feet laminated graphitic tuff with up to 4% pyrrhotite and traces of chalcopyrite were intersected. Assays were not reported.

MILDRED LAKE PROPERTIES (1-J)

In 1954, the company drilled two diamond drill holes north from the south shore of Mildred Lake. This drilling totalled 1120 feet. The drilling tested a peridotite intrusion covered by the waters of Mildred Lake. The intrusion is indicated by a magnetic anomaly and this anomaly is referred to as Wagner's Anomaly 14a by the company. Reports by the company (Macauley 1962d) suggest that drilling was for copper-nickel sulphide mineralization similar to that found at the former Lakemount Mines property in Esquega Township. Drilling intersected up to 5% pyrite in quartz-calcite fractures cutting the peridotite, however, the peridotite itself was barren. Samples from the area were tested unsuccessfully by the company for vermiculite. In the writers opinion this intrusion is likely younger in age than the mineralized Sunrise Lake Intrusion in Esquega Township and is likely equivalent in age to the equally barren Lena Lake peridotite intrusion.

MORAN LAKE (1-K)

In 1966, the company drilled a deep diamond drill hole from the north shore of Moran Lake, northward to Talbot Lake. This hole totalled 1256.0 feet. The hole failed to encounter sulphide mineralization or iron formation.

WALLBANK LAKE (1-L)

In 1952, the company completed three vertical holes from the ice of Wallbank Lake to test for the presence of iron formation. Holes 1223 and 1225 encountered banded iron formation and hole 1226 encountered

approximately 28 feet of limonitic material most likely derived from oxidized carbonate and sulphide facies iron formation. Drilling totalled 835.0 feet. The position of the drill holes is indicated on Figure 68.

ANDERSON PROPERTY (2)

The Carl Anderson property consists of two patented claims, 8263 and 8264 located in the central part of Chabanel Township. A series of samples were taken in a line due west from the Magpie River by persons unknown and checked for gold (AFRO). The best reported assay was 0.04 ounces Au per ton (AFRO); most assays were nil or trace. The claims are underlain by intermediate to mafic metavolcanic rocks and metasedimentary rocks.

BOLIDEN SHOWING (3)

The Boliden showing occurs within intermediate to felsic metavolcanic rocks at the west end of Legarde Lake, was extensively trenched before 1936. Work consists of 13 trenches and two pits (AFRO). The showing was not examined during the present survey.

ERIE CANADIAN MINES LIMITED

The showing was examined by Erie Canadian Mines Limited in 1936.

HOLLINGER CONSOLIDATED GOLD MINES LIMITED

The most recent sampling by Hollinger Consolidated Gold Mines Limited in 1938 resulted in mostly nil assays for gold, the occasional value up to 0.02 ounces per ton and one value of 0.04 ounces per ton (AFRO).

CANAMAX RESOURCES INCORPORATED

Canamax Resources Incorporated completed airborne magnetic and electromagnetic surveys over Legarde Lake in 1983. The survey indicated an electromagnetic conductor in Legarde Lake on strike with the Boliden showing. No follow up work was reported (AFRO).

ELEANOR IRON RANGE (4)

The Eleanor Iron Range (Siderite Hill) occurs in a wedge shaped fault-bounded block of supracrustal rocks. The west and east sides of this wedge shaped block are bounded by branches of the Mildred Lake Fault. Movement along the east branch of the Mildred Lake Fault has transposed a small part of the iron formation on top of the main range. This small part of the iron formation has been mined by open cut and is referred to by Algoma Ore Properties as the Ham Lake Ore Body.

The Eleanor Iron Range is approximately 790 m long and 76 m wide. The siderite facies of the iron formation is approximately 33 m thick. The iron formation occurs between first and second cycle metavolcanic rocks and dips vertically (Plate 38).

The Eleanor Iron Range was part of mining locations 9 and 14 issued to

a J.W. Johnston in 1871. The iron formation cropped out along the Grasset Trail which was heavily used in the 1880's to transport rail equipment to the construction site of the Canadian Pacific Railway. There was probably some prospecting work completed on this range before 1900 (MDIR, Toronto). The locations covering the iron range were acquired by Algoma Ore Properties in 1948 (MDIR, Toronto). Following the acquisition the company completed an extensive program of exploration on the property.

JAMES RICHARDSON AND SONS LIMITED

In 1948, James Richardson and Sons Limited completed 7 diamond drill holes in lot 9 along the southern margin of the Eleanor Iron Range. This drilling totalled 5,826 feet.

ALGOMA ORE PROPERTIES LIMITED

Algoma Ore Properties completed 4 X-ray holes totalling 362 feet in 1948 and 4 NX series holes totalling 875 feet in 1950.

The above drilling plus subsequent surface drilling are described in Table 12. The locations of these drill holes are indicated in Figure 66. Between 1948 and 1966, Algoma Ore properties completed 58,659 feet of surface diamond drilling on the property. Records of Algoma Ore Properties often refer to the Eleanor Iron Range as Siderite Hill.

Between 1956 and 1957, stripping of the deposit, building of a railroad spur to the property and construction of surface facilities was completed. Production started in 1958 from the Sir James Dunn open pit mine and continued until 1967. A total of 5,553,297 tons of waste rock was removed and a total of 7,790,632 tons of siderite ore produced (MDIR, Toronto).

In 1966, a incline was started on the north side of the pit in preparation to recover underground reserves. Work on the incline was terminated before completion and all work ceased on the property in 1967. Preproduction reserves were given at 80,000,000 tons of which 8,000,000 tons were recovered by open pit (MDIR, Toronto). All equipment and most structures have been removed from the property.

HELEN IRON RANGE (5)

The Helen Iron Range is the most productive in the Wawa area. It has a strike length of approximately 2,500 m and varies from approximately 90 m in width at the east end to approximately 330 m at the west end. The iron range is terminated by the Talbot Lake Fault at the west end and the Wallbank Lake Fault at the east end. The great thickness of the iron formation at its west end is due to tectonic activity along the Talbot Lake Fault which thickened the iron formation by drag folding. Drill logs and maps prepared by Algoma Ore Properties indicate that the siderite ore horizon at the east end of the ore zone is approximately 33 m thick and at the west end approximately 66 m thick. The iron formation lies between intermediate to felsic metavolcanic rocks to the south and intermediate to mafic massive and pillowed metavolcanic rocks to the north. The iron range separates first and second cycle volcanisms.

The siderite ore pinches and swells with depth Figure 67 and thickened sections plunge at approximately 60° to the southeast (Canadian Mining Journal 1956). The plunge of the ore bodies is parallel to the long axes of stretched clasts in the footwall tuffs and to the plunge of fold axes of minor folds in the iron formation.

The stratigraphic section is monoclinial, faces north and dips approximately 80°S. The section is overturned and the mining hangwall is the stratigraphic footwall.

Rupert (1979, p.57) described the corporate history of iron mining on the Helen Iron Range as follows:

"Ore zones of the iron formation on Helen Mountain have been operated under several names, by the Algoma Steel Corporation and affiliated or predecessor companies. Names used include Helen Mine, Old Helen Mine, New Helen Mine, Victoria Mine, Alexander Mine and the G.W. MacLeod Mine. Distinctions between these operations are based on division of ore zones by pillars or on the basis of tax accounting procedures. All of the mines are based on a deposit which consists of a single stratigraphic ore horizon of siderite with some faulting or other minor discontinuities and informally it is all known as the Helen Mine."

The Helen Iron Range was staked by B. Boyer, J. Sayer and A. Goetz in 1897 and 1898 (Rupert 1979, p.58). The iron deposit may have been found at an earlier date. The original claim covered a conical hill at the east end of Boyer Lake where the iron formation cropped out.

Rupert (1978, p.58) described the transfer of the original claims to the Algoma Steel Corporation Limited as follows:

"According to Michael (1926), Boyer and Sayer were partners and Mr. Alois Goetz was a third member of the rather loose partnership. Boyer and Sayer sold their claims to Mr. F.H. Clergue, an entrepreneur in Sault Ste. Marie. Mr. Goetz staked one claim for himself and several others under the licences of friends and relatives, then sold them to Mr. A.C. Ely of the Minnesota Iron Company in 1899. All of these original claims were acquired by Mr. Clergue for the Lake Superior Corporation and eventually passed into the Algoma Steel Corporation Limited. Exploration diamond drilling to define the ore was completed in 1898 and by July 1900, a railway to Michipicoten Harbour was constructed and a shipment of ore was made."

With the arrival of the railway in 1900 production of goethite-hematite ore began from the oxidized outcropping of siderite facies iron formation. The ore was loaded directly into rail cars for transport to Michipicoten Harbour where it was transferred to lake freighters for shipment to steel mills in the south. The oxidized ore was a direct shipping ore. Mining of the oxidized cap continued from 1900 to 1918 and resulted in the recovery of 2,780,236 tons of hematite-goethite grading 53% iron and 51,930 tons of pyrite (MDIR, Toronto). Part of the oxidized ore was recovered by the No.1 Shaft which was started in 1901 and reached a final depth of 450 feet in 1909. Another portion of the oxidized ore was recovered by the No.2

Shaft began in 1902 which reached a depth of 650 feet by 1915.

An inclined shaft was completed from level 4 to surface and the No.2 Shaft extended to a depth of 821.7 feet by 1918.

Mining ceased in 1918 but shipments of pyrite continued until 1920.

The presence of siderite at the Helen Iron Range was known before 1900 and was tested via the No.2 Shaft and a 890 foot adit was completed in 1918 from the north side of the iron range before operations terminated in late 1918. Technology to mine and beneficiate the siderite into a desirable commercial product were being developed at this time at the Magpie Mine, Leclaire Township and will be discussed in a following report.

The secondary hematite-goethite ore bottomed in primary siderite which became the object of renewed mining interest in 1937. Important events in the development of the Helen Iron Range (MDIR, Toronto) are as follows:

1899. Stripping, test pitting, driving adits, railroad construction.
1900. Completion of 12 mile (19.2 km) railroad to Michipicoten Harbour. Adit driven into Helen Mill for 260 feet (79.4 m). A tramway for ore transport was completed. Drainage of Boyer Lake started and open pit mining started. Diamond drilling is reported to have been completed but records could not be located.

1901. Open pit mining to a depth of 168 feet (51.2 m) and shaft No.1 sunk to 100 feet (30.5 m).

1902. A second shaft (No.2) sunk for 198 feet (60.4 m) with drifts under Boyer Lake.

1903. Number 1: shaft reaches 168 feet (51.2 m). Diamond drilling totalling 3,425 feet reported complete. No record exists for this drilling.

1905. Number 1 shaft reached 286 feet (87.2 m).

1906-1909 Number 1 vertical shaft reached 428 feet (130.1 m) and 4 levels established.

1910-1915. Number 2 vertical shaft deepened to 682 feet (207.9 m) and 9 levels established. A 4 compartment shaft was sunk below level 4 and the upper levels abandoned. An inclined shaft at 60' was completed to connect with the fourth level. The siderite ore below the hematite-goethite cap explored by diamond drilling.

1916-1917. Surface diamond drilling and some trenching completed.

1918. A 890 foot (271.3 m) adit completed from north side of Helen Hill along with 507 feet (154.5 m) of drifting to examine the siderite zone. Open pit mining ceased.

1937. Construction started on Sinter Plant and adit driven into Helen ore body at Helen Iron Range.

1938. Construction of Sinter Plant continued. Adit reaches 977 feet. Surface trenching totaling 7,920 feet completed.

1939. Open pit mining of siderite from Helen ore body. Ore transported to Sinter Plant by tramway.

1943. Surface diamond drilling and trenching completed. No.3 vertical shaft sunk to a depth of 272 feet.

1945. A second open pit went into production. This pit is the Victoria and lies east of the two large diabase dikes that cut the iron formation. Construction of a sink-float plant started so that silica could be removed from the ore. Surface diamond drilling continues.

1946. Helen open pit abandoned.
 1947. No.3 shaft deepened to 921 feet and 3 deeper levels established. Limited surface diamond drilling completed.
 1949. Underground mining of siderite from Helen ore body begins. Sink-float plant destroyed by fire and plant rebuilt. Sink-float plant has a 3,000 ton per day capacity. A new Sinter Plant constructed. Limited surface diamond drilling continued.
 1950. Victoria open pit abandoned. Helen underground mine in full production. The sink-float plant was closed. Limited surface diamond drilling.
 1951. Underground mining of Victoria ore body begins and Alexander ore body discovered. Surface diamond drilling continues.
 1952. Underground development of Alexander ore body begins. Surface diamond drilling completed.
 1953. Vertical shaft No.5 started and reached 283 feet. This shaft is the MacLeod shaft. Number 4 winze started from second level of Helen ore body to 283 feet below the third level. Surface drilling continues and sink-float plant reopened.
 1954. The No.5 shaft reaches a depth of 1,895 feet. Number 4 winze deepened another 771 feet. A 1,800 foot long inclined 22 $\frac{1}{2}$ ° tramway was driven and tied to aerial tramway.
 1955. No.5 shaft completed 2,066 feet and tramway extended to 4,410 feet. Mining is from all three ore bodies. Number 4 vertical winze reaches a depth of 1,778 feet. The bottom of No.5 shaft is 1,827 feet below sea level.
 1956. Construction of new Sinter Plant and some surface diamond drilling.
 1957. Underground tramway extended to 4,877 feet and a vertical depth of 1,827 feet below sea level. Some surface diamond drilling.
 1959. Surface diamond drilling.
 1960. Production from old Helen ore body ceased. The ropeway was opened to transport ore to the Sinter Plant. The ropeway transports ore from underground crushers through a 1 mile tunnel and a 2 mile aerial tramway.
 1961. Limited surface diamond drilling.
 1962. Helen No.3 shaft and facilities abandoned and operation moved to MacLeod No.5 shaft.
 1974. Work starts on Cable belt in May 1974. Shaft deepening of 262 feet to a final depth of 2788 feet is begun.
 1976. Shaft deepening completed.
 1978. Cable belt tunnel completed. Total length 31,760 feet.
 1979. Cable belt installation tested and operational.
 1980. Ropeway abandoned.

From 1939 to 1984, approximately 79,491,926 tons of siderite have been produced from the Helen Iron Range. In 1984, the reserves were given in the annual report of the company as 58,246,000 tons long tons grading 33.7 to 34.5% Fe and 8.37 to 8.83% SiO₂. The siderite facies of the iron formation extends to depth and the limits to mining will be determined by economics rather than a lack of siderite. Table 13 presents a tabulation of surface diamond drilling completed on the Helen Iron Range. Figure 68 presents the location of the diamond drill holes and additional

development data on the deposit. On the M-3 level galena-filled fractures have been encountered in mining operations. A grab sample collected by the field party of this material returned 144 ppm Ag and 31.2% Pb (Geoscience Laboratories, Ontario Geological Survey).

HEMGOLD RESOURCES LIMITED (6)

In 1983, Hemgold Resources Limited completed an airborne magnetic and electromagnetic survey at a scale of 1:15 840. This survey covered the northwest corner of Chabanel Township. No additional work has been completed. The airborne survey disclosed the presence of a number of conductive horizons.

JALORE MINING COMPANY LIMITED (7)

The Jalore Mining Company Limited completed an intensive exploration program for iron in the Wawa area during the early 1950's. The most intense work was completed on the Ruth and Lucy Iron Ranges. The work completed by the company on the various iron occurrences within the map area will be described under the relevant iron ranges or iron occurrences.

LUCY SAND FLATS (7-A)

The company completed 5 short diamond drill holes totalling 644.4 feet on patented claims S S M 23011 in 1952. All holes were completed from the same drill set up. The reasons for this drilling are unknown. The drill logs fail to indicate significant mineralization. The position of the holes and interpretation of the logs suggests that the holes intersected the massive to pillowed intermediate to mafic metavolcanic section just below the mafic breccia unit that forms a distinct stratigraphic unit separating mafic and felsic metavolcanic rocks of cycle one.

JOHNSON IRON RANGE (8)

This iron range lies on Johnson Mining locations 10 and 11 which are two of a series of mining locations granted to J. Johnston in 1871. The name for this range is sometimes spelled with a "T" however most recent reports refer to it as the Johnson Iron Range. Moore and Armstrong (1946) include the eastern part of this range with the Eleanor Iron Range and existing records are commonly intermixed with data on the Eleanor Iron Range. The author defines the Johnson Iron Range as has Goodwin (1963). The Johnson Iron Range is that segment of Michipicoten Iron Formation bounded by the Wallbank Lake Fault to the west and the west branch of the Mildred Lake Fault to the east.

Little information on the early history of this iron range could be located. Willmott (1898, p.195) indicated Johnson prospected his claims by trenching many years before his visit. This prospecting activity was unsuccessful and may have been directed to finding copper and silver (Willmott, 1898, p.195). Trenching on this range had occurred by 1947 (AFRO). Diamond drilling and mapping indicate the range is approximately 3350 m long and reaches a maximum width of 46 m. The iron formation

faces north and dips vertically to steeply south. The iron range separates intermediate to felsic metavolcanic rocks at the top of cycle one from intermediate to mafic metavolcanic rocks of cycle two. Brecciation of the iron formation along with pinching and swelling suggest to the author that shearing or faulting has occurred parallel to bedding. Unsigned reports prepared by Algoma Ore Properties indicate the iron formation east of Wallbank Lake is brecciated and that some facies of iron formation are locally missing (AFRO). Faulting of the iron formation was suggested in these reports.

In 1948, Algoma Ore Properties undertook an extensive diamond drill program to evaluate the more promising part of the iron range. In 1948, the company completed 6,397 feet of diamond drilling in 25 holes and in 1950 the company completed an additional 5 holes totaling 6,620 feet in a deep diamond drilling program.

The locations of the holes are given in Figure 69. The reader should also refer to Figure 68 for the location of the Johnson diamond drilling with respect to the Helen Iron Range. Table 14 gives the assay data on siderite intersected in the deep diamond drilling programs.

LUCY IRON RANGE (BROOKS LAKE IRON RANGE) (9)

The Lucy Iron Range is bounded by the Mildred Lake Fault to the west and the Bauldry Lake Fault to the east. The range strikes north of east and dips vertically. The range is approximately 3050 m long and has a maximum width of approximately 91 m. As with the other Michipicoten Iron Ranges, it occupies a position separating first and second cycle volcanism. The Lucy Iron Range is the faulted eastern extension of the Eleanor Iron Range. Exploration work completed on the Iron Range indicate it is cut by numerous small faults. Collins and Quirke (1926, p.161) refer to this iron formation as the Brooks Lake Iron Range.

The diamond drill indicated distribution of the siderite unit is indicated on Figure 70. The Lucy Open Pit is sited in the thickest section of the siderite unit located northwest of Brooks Lake.

In 1899, or shortly before, A. Goetz staked the Lucy Iron Range for its iron potential (McKee ?). In 1908, A. Goetz completed extensive trenching on the range. Evidence of this trenching remains to this day. The property was examined in 1911 by W.M. Goodwin for the Algoma Steel Corporation Limited, however, no additional work was reported (Collins and Quirke 1926, p.89).

MICHIPICOTEN IRON MINES LIMITED

In 1941, Frobisher Exploration Company Limited obtained control of the iron range from Mr. Goetz. The property became known as Michipicoten Iron Mines after 1942 (Moore and Armstrong 1946, p.74, MDIR, Toronto). Michipicoten Iron Mines is presently controlled by Sheritt Gordon Mines Limited who control 67% of the company (Canadian Mines Handbook 1983-1984, p.238).

JALORE MINING COMPANY LIMITED

In 1947, the Jalore Mining Company Limited optioned the property and

began a program of diamond drilling and geological mapping.

In 1949, Jalore Mining Company Limited exercised its option on the Lucy Iron Range from Sherritt Gordon Mines and Frobisher Exploration Company Limited (Canadian Mines Handbook 1949, p.113). During the next several years the company completed geologic mapping and a large diamond drill program on the property totalling 35,164 feet. Jalore Mining Company Limited terminated the lease arrangement in 1955 (Canadian Mines Handbook 1955, p.103).

ALGOMA STEEL CORPORATION LIMITED

In 1967, the Algoma Steel Corporation Limited optioned and proceeded to develop the property for open pit production (Canadian Mines Handbook 1967-1968, p.219). This option was for 99 years (MDIR, Toronto). Algoma Steel Corporation Limited operated the Lucy Open Pit Mine from 1967 to 1970 producing 1,107,773 tons of siderite from the west-central part of the range. The annual report of the Algoma Steel Corporation Limited in 1978 indicate a 1,300,000 ton reserve at Lucy of unspecified grade. During development the company completed an additional 44 surface diamond drill holes totalling 6,198.5 feet (AFRO).

The work by Michipicoten Iron Mines, Jalore Mining Company Limited and Algoma Ore Properties Limited took place simultaneously on both the Lucy and Ruth Iron Ranges. Consequently, various grade and reserve calculations given in various reports are commonly a combination from both iron ranges. Hames and Gallie (1956, p.3) indicated that the reserves for the Lucy were 3,713,000 tons open pit ore and 12,319,000 tons underground. Jarvis (1966, p.1) indicated that the total recoverable open pit ore for both the Lucy and Ruth Iron Ranges was 5,545,000 tons and that the removal of 6,334,000 tons of waste would be required.

Estimates of open pit ore in place are compiled from Jarvis (1966, p.1) and given in Table 15. The location of the diamond drill holes are given in Figure 70 and tabulated in Table 16.

MAGPIE JUNCTION GOLD OCCURRENCE (10)

The Magpie Junction Gold occurrence occurs just west of the junction of the former Magpie Mine railway spur with the Algoma Central Railway spur line between Hawk Junction and Wawa. The showing is exposed in a railway cut and consists of a silicified and carbonated mafic intrusion with visible pyrite and arsenopyrite. The pyrite and arsenopyrite are disseminated. The pyrite was estimated by the writer to compose 20 to 40% and arsenopyrite 2 to 4% of the best mineralized samples.

The Magpie Junction Gold occurrence has a long history. The date of discovery is unknown but the showing is exposed in a railway cut and would have certainly been seen at the time of railway construction. Two claims covering the showing were owned by W. Soulier prior to 1938.

REGNERY MINES LIMITED

Regnery Mines Limited optioned the showing from Mr. Soulier sometime prior to 1938 and staked an additional 30 claims in the area. Records of

the work completed by this company are essentially non-existent. A plan map found in the files of Hollinger-Argus Limited, Timmins indicate that Regnery Mines Limited completed trenching, assaying and 15 diamond drill holes prior to 1938. From the plan map this drilling is estimated to be a minimum of 4,106 feet. Table 17 gives the results of this work as indicated on the plan map. Figure 71 presents the location of the Regnery Mines Limited drilling.

ERIE CANADIAN MINES LIMITED

Erie Canadian Mines Limited examined the property in 1938. The company took two grab samples, one each from trenches 2 and 3 and obtained Au values of 2.80 dwts (0.14 oz/ton).

ALGOMA CENTRAL AND HUDSON BAY RAILWAY COMPANY

In 1963 and 1964, the Algoma Central and Hudson Bay Railway Company completed sampling, geological mapping and electromagnetic and magnetic surveys over the property. At this time claims covering the showing were held by J. H. Hough of Sault Ste. Marie. Eight grab samples collected by the company in 1963 ranged from nil to a maximum of 0.07 ounces per ton (AFRO). Except for one sample all were 0.04 ounces per ton or less. The best value came from the south end of trench 4 (AFRO).

HUCLIFF PORCUPINE MINES LIMITED

In 1973, Hucliff Porcupine Mines Limited optioned two claims covering the showing and had a report prepared on the occurrence. Two samples were collected for assay. One grab-chip sample taken from trench 2 from 40 to 98 feet south of the northeast end of the trench returned 0.10 ounce Au per ton (AFRO). A second grab-chip sample from trench 3 from 25 to 70 feet south of the north end of the trench returned 0.02 ounce Au per ton (AFRO). No additional work was reported.

CANABEC EXPLORATIONS LIMITED

In 1977, Canabec Explorations Limited completed sampling of old trenching, a V.L.F. electromagnetic survey and in 1978 diamond drilling. A total of 7 holes totaling 2,489.5 feet were completed. The results of the trench sampling and best intersections encountered in diamond drilling are given in Table 18. Assays for the diamond drilling are commonly 0.03 ounces per ton to nil. The positions of the Canabec Resources Limited drill-holes are indicated on Figure 71.

CANAMEX RESOURCES INCORPORATED

In 1983, Canamex Resources Incorporated completed airborne magnetic and electromagnetic surveys over the property. These surveys failed to indicate anomalous magnetics or conductivity. No additional work was completed. Ground electromagnetic surveys by Canabec Explorations Limited did indicate a north- to northeast trending anomaly in the gold-bearing zone. The encouraging values found by Regnery Mines Limited have

not been duplicated in subsequent investigations. The area is anomalous in gold but values are presently subeconomic. This is the only gold showing within this report area that is located in second cycle or perhaps third cycle volcanic rocks. The showing is located within intermediate to mafic intrusive rocks rather than the surrounding volcanic rocks of cycle two or three.

MAMMOTH METALS LIMITED OCCURRENCE (11)

A quartz vein containing coarse-grained galena, sphalerite and arsenopyrite was found on the south shore of a small lake by G. Christie and W. Souliere in the fall of 1927. The showing became known as the Christie showing. The vein strikes at approximately 70°, dips 30 to 50°N and varies from 12 to 15 inches in width. The vein cuts massive fine- to medium-grained equigranular quartz-diorite. Up to 10% fine-grained bluish quartz is present in some samples of the quartz diorite host rock. At the time of the author's visit the workings were partially filled and covered. Cliff (1928, p.4) reported that the vein has a strike length of at least 125 feet before being faulted off. Cliff (1928, p.4) reported the faulted extension of this vein was found 500 feet west of the original showing and it contained galena.

Mr. Soulier and Mr. Christie sold half interest in their find to a J.J. Gower (Cliff 1928, p.17). On the strength of the Christie-Soulier find, a Mr. O'Keefe staked a claim covering a quartz vein north of the Christie showing. The quartz vein became known as the O'Keefe Vein. The O'Keefe Vein was reported to contain galena but Cliff (1928, p.5) reported that he could not find galena. Booth (1947) reported finding the O'Keefe Vein and described it as a series of folded quartz veins dipping 30°N and containing very minor amounts of pyrite and galena. He described the veins as occurring in sheared rhyolite. The O'Keefe Vein lies close to the contact of the quartz diorite with intermediate to felsic metavolcanic rocks on the basis of mapping by the field party.

Coarse-grained galena and sphalerite occur with milky quartz in the Christie vein while most of the arsenopyrite is concentrated along the walls of the vein or in the immediately adjacent wall rock. Table 19 is a listing of grab samples taken by the field party for assay from the Mammoth Metals Limited occurrence. Figure 72 shows the approximate location of the samples which were taken from the rock piles next to the trenches by the field party. The assay data indicates little gold potential but there are interesting to high grade silver values in the galena-bearing samples.

DOMES MINES LIMITED

On the basis of high silver and lead assays, Dome Mines Limited optioned the Christie property from the discoverers in 1927. The company completed trenching on the property and three diamond drill holes totalling 500 feet. This drilling failed to encounter mineralization of interest and the option was dropped.

MAMMOTH METALS LIMITED

Mammoth Metals Limited incorporated in 1928 and took over the property. Moore (1931, p.41) reported that the company sank two shafts on the property and shipped a few tons of galena. No additional work has been reported by the company and its charter was cancelled in 1955 (Canadian Mines Register, Dormant and Defunct Companies, p.236). The author could not locate the shafts. Geological maps of the property prepared by Algoma Ore Division in 1967 indicate one shaft and some pitting 600 feet northeast of Woodduck Lake (local name). The position of this shaft is indicated on the accompanying compilation map for the township. Booth (1947) reported the work by Mammoth Metals Limited was completed in 1929 and that an inclined shaft 65 feet was sunk and 165 feet of drifting completed. A memorandum by G.S. Gilbert (1947) from the files of Algoma Ore Properties Limited indicated that sampling by a H.S. Robinson (1928) over widths from 8 to 40 inches returned trace to 3.31 ounces Au per ton and 0.44 to 65.12 ounces Ag per ton.

ALGOMA ORE PROPERTIES LIMITED

In 1967, Algoma Ore Properties Limited prepared a geological map of the property at a scale of one inch to 100 feet. A magnetometer and electromagnetic survey was also completed over the property. Grab samples by the company returned trace to nil gold and nil to 63.26 ounces Ag per ton. No other work was reported. Cliff (1928, p.4) reported that a vein similar to the Christie showing occurs on Algoma Steel Corporation Limited ground to the west. Cliff (1928) reported work had been completed on this showing. The author could find no evidence of this showing on maps or in the files of the Algoma Steel Corporation Limited.

MANZUTTI PROPERTY (12)

A. Manzutti owned 18 claims in 1937 west of the power dam at Steep Hill Falls. He reported trace amounts of gold from samples collected on the property (AFRO, Toronto).

E. METVEDT PROPERTY (13)

Between 1957 and 1958, E. Metvedt completed 37 short diamond drill holes on a group of claims near the old tractor road from the Algoma Control Railway tracks to Steep Hill Falls. This drilling totalled 2847.1 feet and was directed towards the search for base metal mineralization. The work was completed for Sherritt Gordon Mines Limited and the claims were referred to as the Track Group. Assay data from this work is unavailable. Mapping in the area by the field party indicates the presence of two narrow gossan zones with some weathered pyrite. One sulphide zone occurs at or very close to the intermediate to mafic metavolcanic-metasedimentary contact and the second occurs approximately 30 to 50 m below the contact within intermediate to mafic metavolcanic rocks. The metavolcanic rocks consist of pillowed and massive flows and breccia units and the metasedimentary rocks are thinly bedded wackes and siltstone. The metasedimentary rocks display excellent graded bedding and flame structures. Facing directions in the metasedimentary rocks and metavolcanic rocks are consistently southwest and the section dips 40 to

60|NE. The metavolcanic-metasedimentary contact is conformable and the stratigraphic section overturned. Figure 73 gives the position of the diamond drill holes completed by Mr. Metvedt.

MILDRED IRON RANGE (14)

The Mildred Iron Range occurs on the north flank of an anticlinal structure in cycle one intermediate to felsic metavolcanic rocks. The iron formation pinches and swells and has been attenuated during folding. Intermediate to felsic metavolcanic rocks generally occur south of the range and intermediate to mafic metavolcanic rocks to the north. The dominant facing direction of this area is south; however, on the basis of lithologic distribution when compared with less deformed areas within the Wawa supracrustal rocks, the facing direction should be north. The iron formation strikes north of east, dips 70 to 80|S and is thus overturned. The iron formation reaches widths of 107 m. Isolated segments occur along the mafic-felsic metavolcanic contact east of the indicated eastern termination of the iron formation. The author as does Goodwin (1964, p.687) consider the Mildred Iron Range to be the western extension of the Helen Iron Range which has been displaced by folding and faulting. The Mildred Iron Range has a strike length of approximately 3655 m with approximately 1525 m within Chabanel Township and 2130 m (Mandziuk and Studemeister 1980) lying in adjacent Bailloquet Township to the west.

The Mildred Iron Range was staked by A. Goetz and G. Goetz around 1906 (Collins and Quirke 1926, p.82). From 1906 to 1908, the range was trenched at intervals of 60 feet (Collins and Quirke 1926, p. 82; Coleman 1906, p.181-183). Coleman (1906, p.181-183) examined trenching completed on the range and prepared an idealized cross section. In 1948, Marsden (1948, p.2) indicated the claims were under the control of M. Goetz from whom an option was secured by the Jalore Mining Company Limited.

JALORE MINING COMPANY LIMITED

The Jalore Mining Company Limited completed a dip needle survey over the Mildred Iron Range, a geologic map of the property and drilled 3 short diamond drill holes. The drilling totalled 983.75 feet. This work disclosed the presence of only subeconomic quantities of siderite. Figure 74 is a simplified sketch of the geology as mapped by Jalore Mining Company Limited with the position of the 3 diamond drill holes indicated.

MILE 12 IRON FORMATION (15)

A small band of iron formation occurs along the Algoma Central Railway tracks approximately 19 km west of Hawk Junction and east of Legarde Lake (Collins and Quirke 1926, p.88). This area was mapped in 1951 by Jalore Mining Company Limited and 4 segments of iron formation were uncovered at 23 km (mile 14.5 on Algoma Central Railway branch line to Wawa) (Young et al; 1951, p.2). The occurrences described by Young et al (1951) are thought to be the same ones described by Collins and Quirke (1926) even though the distances from Hawk Junction are considerably different.

Young et al (1926, p.2) reported that the largest block of iron formation is approximately 100 by 100 feet. This very small occurrence is unlikely to have any commercial interest.

MILLER GROUP (16)

A group of 9 claims was staked between Legarde Lake and the Magpie River prior to 1937. This group of claims came to be known as the Miller Group. The showing consists of quartz veins cutting quartz diorite.

HOLLINGER CONSOLIDATED GOLD MINES LIMITED

In 1937 Hollinger Consolidated Gold Mines Limited examined previous trenches and took 14 samples. One sample returned 0.02 ounces and one 1.88 ounces Au per ton (AFRO, Toronto). All other samples returned nil values. The position of the samples is unknown. Sketch maps of the Hollinger Consolidated Gold Mines Limited data suggest that the quartz veins were extensively sample and that the vast majority of the samples returned nil gold with the occasional value of 0.02 ounces Au per ton (AFRO, Toronto).

ERIE CANADIAN MINERAL LIMITED

In 1938 Erie Canadian Mines Limited examined the property and sampled two trenches that had exposed diorite with quartz veining. Samples from one trench returned 0.02 ounces ton and the other 0.02 to 0.12 ounces Au per ton. No additional work has been reported from the area.

PHELPS DODGE CORPORATION OF CANADA LIMITED (17)

In 1975, Phelps Dodge Corporation of Canada Limited completed 3 diamond drill holes in what appears to be a follow-up to an airborne electromagnetic survey. Two holes were completed in Chabanel Township and one was completed just west of the Chabanel-Bailloquet Township line. The diamond drill holes are discussed individually.

GRID NORTH (17-A)

Hole 143-1 totalling 224 feet was completed in Bailloquet Township just west of the boundary with Chabanel Township. The drill log indicates the presence of quartz diorite, greenstone tuff and rhyolite (AFRO, Toronto). Magnetite is indicated to be present in the metavolcanic rocks and diorite. From 92.5 to 94 feet pyrrhotite composes 5% of the rock and from 189 to 197 feet a zone of barren pyrite and pyrrhotite is reported to be present (AFRO, Toronto). Thin seams of pyrrhotite are also present at 205 and 212 feet. Assay results were not reported.

GRID WEST (17-B)

Hole 143-2 totalling 172 feet was drilled in an area of glacial outwash in the west-central part of Chabanel Township. The drill log indicates a dominantly felsic metavolcanic lithology. From 107 to 111 feet, the

drill log indicates 30% pyrrhotite and pyrite with traces of chalcopyrite of over a width exceeding 3.0 feet (AFRO, Toronto). Assay data were not reported.

GRID WEST (17-C)

Hole 143-3 totalling 200 feet was completed in the west-central part of Chabanel Township. The drill log indicates fragmental felsic metavolcanic rocks. The drill log indicates that between 5 and 59 feet 20% pyrite and 5% pyrrhotite occur as bands 1/8 to 1/4 inches thick (AFRO, Toronto). Between 59 and 72 feet narrow seams of 12% pyrite were reported. Assay data are not available.

SINCLAIR PROPERTY (18)

The Sinclair property is located along the south shore of Brooks Lake along the contact between a mafic breccia and pillowed mafic metavolcanic rocks. Samples collected by C. R. Sinclair in 1938 were analysed for gold by Erie Canadian Mines Limited. All samples contained only a trace of gold.

E. METVEDT

In 1957, E. Metvedt working on the same ground as the Sinclair claims completed 7 short diamond drill holes totalling 418 feet. This work was done for Sherritt Gordon Mines Limited and the property at that time was called the Brooks Lake Group. The work was probably done in the search for base metals. No assays were reported.

WILKS-ARNOTT IRON RANGE (19)

The Wilks-Arnott Iron Range occurs accompanying a mafic flow in a section of clastic metasedimentary rocks above the Lucy Iron Range. The geologic setting of this iron formation is unique, as the author has not observed iron formation in this stratigraphic position in other places within the greenstone belt. The extent of this iron formation was recently outlined by Thomas (1984) as part of his study of the metasedimentary rocks. The iron formation overlies a massive mafic flow and is in turn overlain conformably by an argillite unit that is 10 m thick (Thomas 1984, p.19). Thomas (1984, p.28) interprets the metasedimentary rocks associated with the iron formation to have been deposited in a lacustrine or basinal environment.

The Wilks-Arnott Iron Range was interpreted by Thomas (1984, p.19) to have a strike length of 240 m. On the basis of diamond drilling by Jalore Mining Company Limited, the iron formation reaches widths of 7.0 m. The range strikes just north of east and faces north.

One large sample collected by the author was slabbed and polished. The polished surface indicated pyrite concretions up to 3 cm in diameter, angular crustiform (algal mattes) fragments of pyrite and angular chert fragments set in an oxidized matrix. In the surrounding metasedimentary rock, laminated chert is a common, if not almost exclusive pebble type within some of the conglomerates. This suggests that a unit of iron

formation was actively being eroded in the stratigraphic section below the Wilks-Arnott Iron Range. The author suggests that this iron formation is in fact a slump or debris flow deposit possibly derived by erosion of Michipicoten-type iron formation lower in the stratigraphic sequence. The underlying mafic flow is not laterally extensive suggesting that the mafic flow and iron formation debris deposit were both topographically controlled at the time of deposition. Collins and Quirke (1926, p.89) mentioned that blue grey siderite with a sprinkling of pyrite occurs at the end of an adit driven into this range. These workings are now inaccessible and the presence of siderite could not be confirmed. A sample of iron formation collected by the field partly from the small pile in front of the adit returned 70 ppb Au (Geoscience Laboratory, Ontario Geological Survey). A spectrographic analyses disclosed nothing of additional interest. Parsons (1915, p.209) reported that this iron range was once known as the Ross-Arnott Claims.

It is uncertain when claims were staked on the Wilks-Arnott Iron Range. The claims had been surveyed and considerable trenching and driving of adits had taken place by the time Collins and Quirke (1926, p.89) visited the range in 1918. Drury (1950, p.1) indicated the claims may have been originally staked in the search for pyrite.

JALORE MINING COMPANY LIMITED

In 1948, Jalore Mining Company Limited optioned the property for a period of 18 months from persons unknown (McKee 1950). The company completed detailed geologic mapping and 7 short diamond drill holes. The drilling totalled 981.6 feet (AFRO, Toronto). The logs indicate an abundance of pyrite but do not mention siderite. McKee (1950) indicated that the core was not analyzed. Drury (1950, p.5) confirmed the presence of siderite in one of the adits in the iron range, presumably the same adit that was examined by Collins and Quirke (1926). Jalore Mining Company Limited terminated their option on the property and no work has been reported since.

WILLIAMSON GROUP (20)

Prior to 1936, a group of claims covering a gold showing was staked by M. Williamson and partners near mileage 14.5 on the Algoma Central Railway spur line between Hawk Junction and Wawa. The showing is approximately 100 m north of the railroad. The property is underlain by intermediate to felsic metavolcanic rocks and cut by mafic intrusions. Gold mineralization occurs in quartz veins. This property was not visited during the present survey. Chip sampling by R. Rupert former resident geologist, Sault Ste. Marie, returned trace to 0.10 ounces Au per ton.

J. ERRINGTON

In 1936, the property was optioned to J. Errington and it was then known as the Rouleau Option. The company prepared a grid and drilled 10 diamond drill holes. The first 9 holes totalled 1,703.5 feet. The length of hole 10 is unknown. Holes 4, 5, 6, 7 and 8 all encountered

values equal or greater than 0.08 ounces Au per ton. The diamond drill grid map can not be located and the position of the assays within the respective holes is unknown. Figure 75 presents the available Errington data.

ERIE CANADIAN MINES LIMITED

Erie Canadian Mines Limited examined the property in 1936 and Channel sampled some pits. This work returned values of trace to 0.14 ounces Au per ton (AFRO, Toronto).

HOLLINGER CONSOLIDATED GOLD MINES LIMITED

Hollinger Consolidated Gold Mines Limited examined the property in 1937 and collected 19 samples. Fifteen samples returned nil gold and the others returned 0.03, 0.04, 0.15 and 0.07 ounces Au per ton. A shaft inclined at 45° was reported to be present on the property at this time.

ALGOMA ORE PROPERTIES LIMITED

In 1944, Algoma Ore Properties Limited examined the property and took two grab samples containing arsenopyrite. These samples returned 0.02 and 0.21 ounces Au per ton (AFRO, Toronto). No other work has been reported.

ESQUEGA TOWNSHIP

AMAX EXPLORATION INCORPORATED (21)

Amax Exploration Incorporated completed one diamond drill hole in the centre of Esquega Township totalling 110 m in 1980. The rocks were described as variolitic mafic flows and tuffaceous greywackes. Sulphide facies iron formation with chert was encountered in three areas of the core. The hole was drilled south and the first iron formation unit encountered is described as graphitic. On the basis of facies distribution of the iron formation units, the stratigraphy faces north. Gold assays reported by the company ranged from nil to 0.85 ppm (AFRO, Toronto). The best value of 0.85 ppm was encountered between 67.5 and 70.1 m. All other Au values were 0.06 ppm or less. Silver values ranged from nil to 0.8 ppm, copper from 63 to 286 ppm, lead from 31 to 99 ppm and Zn from 17 to 3020 ppm. The occurrence had been pitted and trenched prior to the work by Amax Exploration Incorporated. There is no record of when this early work was done.

ALGOMA ORE PROPERTIES LIMITED (22)

Algoma Ore Properties Limited, a division of the Algoma Steel Corporation Limited, completed work in a number of areas of the township. The company has also completed a number of geological traverses within the township for the purpose of regional compilation. The reader should refer to the Assessment Files Research Office, Toronto for the traverse data.

ASSESSMENT DRILL HOLE A-3 (22-A)

Algoma Ore Properties Limited completed one diamond drill hole totalling 962 feet on patented claim S S M 17350 in 1953. The hole encountered rhyolite, diorite and greenstone (AFRO, Toronto). The drill log reports the presence of siliceous pyrrhotite with minor chalcopyrite from 154 to 159 feet and 163.5 to 168 feet. Assay data was not given. The drill log indicates the drill penetrated intermediate to felsic metavolcanic rocks and mafic intrusive rocks (AFRO).

ASSESSMENT DRILL HOLE A-6 (22-B)

Algoma Ore Properties Limited completed one diamond drill hole totalling 571 feet on claim S S M 17348 in 1953. The drill log reports unmineralized peridotite from top to bottom (AFRO).

LOONSKIN LAKE AREA (22-C)

Algoma Ore Properties Limited investigated a series of patented and unpatented claims east and southwest of Loonskin Lake.

In 1955, the company completed a geological map over these claims. Gilbert and Jarvis (1950, p.2) reported obtaining an assay of 0.10 ounces Au per ton on a bulk sample of iron formation from the southeast corner of Loonskin Lake. This iron formation occurs just east of the shoreline of the lake and strikes parallel to the lake but the sample site is not precisely known.

In 1963 the company completed another geological map, a magnetometer survey and an electromagnetic survey over these claims. The presence of copper in veinlets which had weathered to bornite and malachite is reported by Zodrow (1963, p.7). These copper showings were not precisely located and were considered insignificant by the company. No additional work was reported.

MICHIPICOTEN BASE METAL PROJECT (22-D)

As part of the Michipicoten Base Metal Project the Algoma Steel Corporation Limited completed follow-up diamond drilling to test airborne electromagnetic anomalies.

ANOMALY 17C (22-D1)

Algoma Steel Corporation Limited completed one diamond drill hole (MB-1-81) on anomaly 17C in Esquega Township in 1981. This hole totalled 441 feet. From 409 to 412 feet pyrite with minor chalcopyrite is present (AFRO, Toronto). The pyrite is reported to reach concentrations of 8% and occur in a siliceous breccia. The company assayed for gold and silver and completed a spectrographic analysis without finding anything of interest. The highest Au value was 0.006 ounces per ton and the highest Ag value was 0.09 ounces per ton (AFRO, Toronto).

ANOMALY 27D (22-D2)

Algoma Steel Corporation Limited completed three diamond drill holes (MB-16-81, MB-17-81, MB-18-81) on anomaly 27D totalling 289.5 feet in 1981. Holes 16 and 17 failed to identify the conductor. Hole 18 from 71.0 to 77.5 feet intersected banded chert, pyrrhotite and pyrite with a trace of chalcopyrite. This section was assayed by the company and returned 0.005 ounces Au and 0.047% Cu. A spectrographic analysis by the company failed to disclose anything of economic interest.

WAGNER ANOMALY 14B (22-E)

A magnetic anomaly lying beneath Goetz Lake has been referred to as Wagner's Anomaly 14b. Macauley (1962b) interprets the anomaly to be due to a peridotite intrusion similar to these found at Lena and Mildred Lakes. He reported no evidence of copper or nickel mineralization.

ATNEL GOLD OCCURRENCE (23)

The Atnel Gold occurrence (No.3 vein) is located approximately 90 m due east from McEwen Lake in the northwest corner of the township. The gold occurs in quartz veins in silicified, carbonated and sheared diorite that has intruded the metavolcanic rocks. Quartz-feldspar porphyry intrusive rocks intrude the diorite and are in very close proximity to the gold mineralization. Shearing has occurred preferentially in the diorite in close to the contact with relatively unsheared quartz-feldspar porphyry. This showing occurs at the same stratigraphic position and within the same geological setting as the Murray Algoma Gold occurrence located approximately 915 m farther east. There is no known gold mineralization between the two showings. Pyrite is disseminated throughout the mineralized zone and traces of chalcopyrite may be present. The quartz veining is of at least two ages. The earliest veining is white and granular and the latest is milky and coarsely crystalline.

Studemeister (1984a, p.10, 11) has interpreted the host rocks to be a band of reworked tuff.

The mineralized No.3 shear zone strikes 60 to 70°, dips vertically to 75°N and is traceable for a distance of at least 305 m (Studemeister 1984a, p.10). The author concurs with Studemeister (1984a) as to structural attitude of the veining. Hesse (1934, p.10) described the veining to be 2500 feet (762 m) long, striking 40°, dipping 50°SE and varying from 8 to 14 feet in width. The structural observations of the author and Studemeister (1984a) are at great variance with those of Hesse (1934).

Holbrooke (1936, p.2), on the other hand, described the No.3 vein as being within a shear zone along the contact between a quartz-feldspar porphyry intrusion and greenstone, striking 65° and dipping 77°N. The author is also in close agreement with the structural and geological observations of Holbrooke (1935).

Grab samples collected by the field party indicate highly erratic gold values, several of which are relatively high. The samples are listed in Table 20 and their location is given in Figure 76. The late milky coarsely crystalline quartz veins are barren.

ATNEL GOLD MINES LIMITED

The claims covering the Atnel Gold occurrence were staked by George and James Armstrong in 1928 (Knight 1937, p.5). The original find, also known as the Armstrong property, is reported to have been sampled by Parkhill Gold Mines Limited and Hollinger Gold Mines Limited but records for this work do not exist (Knight 1937, p.5). Atnel Mines Limited was incorporated in 1934 (Knight 1937, p.6). Stripping and trenching is assumed to have been done from the time of discovery. Prospecting of the property disclosed a number of quartz veins but the vein known as No.3 Vein was the only one considered to have promise. Drilling by Atnel Gold Mines Limited of 4 diamond drill holes was completed in 1935, however, records for only the first three holes could be located (Hesse 1935). The first three holes totalled 1092 feet. The best assays were on hole 3 from 318 to 321 feet and from 321 to 324 feet. They are 0.36 and 0.32 ounces Au per ton respectively (AFRO, Toronto). Values in the old reports were given in dollars and cents. The author converted to ounces using \$35.00 per ounce Au. The vein mineralization was described in the drill log as vein quartz, pyrrhotite, tourmaline, chlorite and carbonates.

ERIE CANADIAN MINES LIMITED

In 1936, Erie Canadian Mines Limited optioned the property and completed mapping and a sampling program of the No.3 Vein. Sampling was not encouraging and the option was dropped. Mapping by Erie Canadian Mines Limited observed the same structural relations as Studemeister, Holbrooke and the author.

HOWEY GOLD MINES LIMITED

The property was optioned by Howey Gold Mines Limited in 1937 and sampling was completed (Knight 1937). Knight (1937) observed there were high gold values in weathered rock versus relatively low values in fresh rock. He was of the opinion that some of the high values in gold were the results of weathering and enrichment at the surface (Knight 1937, p.2). The sampling was not encouraging and the option was terminated.

UNKNOWN

A 13 hole diamond drill program was completed on the property by persons unknown (Kustra 1961). No mention of this drilling is made by Knight (1937). Kustra (1961) mentioned that this 13 hole diamond drill program was completed by a Mr. Baird. D. S. Baird was very active in the area during the late 1930's and early 1940's (see Lakemount Mines Limited, AFRO, Toronto). Tentatively, the author considers this drilling to have been completed in the late 1930's. The field party located the collars to 5 diamond drill holes which are probably the result of this drill program. Kustra (1961) reported that low assays results for these holes were once present in the files in the Algoma Central Railway Office but they could not be located by the author.

J-Q RESOURCES LIMITED

J-Q Resources Limited staked 52 claims in the north-central part of Esquega Township in 1981. This claim block included the former properties of Atnel Mines Limited and Murray Algoma Gold Mines Limited, with most of the work being completed on the former Atnel Mines Limited occurrence.

In 1983, an additional 6 claims were staked. A grid was cut over the area of the known gold showings. In the fall of 1982, J-Q Resources Limited (60%) went into partnership with Dashar Resources Limited (20%) and Obisico Mines Limited (20%) and completed 8 diamond drill holes on the property. This drilling totalled 1526 feet. Holes one and two were drilled near Reed Lake (local name) and all of the remaining holes were completed on the No.3 Vein of the former Atnel Mines Limited property. The company reported that hole 4 from 37 to 38 feet assayed 0.16 ounces Au per ton. The next best assay was 0.06 ounces Au per ton from 249 to 251 feet in hole 8. All other values reported by the company were 0.01 ounces per ton or less.

In 1983, the company completed some surface sampling and obtained values ranging from nil to 0.86 ounces Au per ton. A chip sample over 7.5 feet along an old trench just west of the main pits on the vein returned the best value of 0.86 ounces Au per ton. All other values reported were 0.005 ounces Au per ton or less. The company completed radiometric and VLF-electromagnetic surveys over the property in 1983. The claims were dropped in 1984.

BELYEA SYNDICATE (24)

The Belyea Syndicate drill tested two widely separated claims in 1963 and 1964. The area was diamond drill tested as it lacks significant outcrop and is largely covered by sand and gravel.

LOCATION 24-A

In 1963 the Belyea Syndicate drilled three diamond drill holes totalling 950 feet on claim AC 7414. This drilling encountered granitic rocks and both lamprophyre and diabase dikes. No mineralization was reported.

LOCATION 24-B

In 1964, the Belyea Syndicate drilled 4 diamond drill holes on claim AC 7318 south of Hawk Lake. This drilling totalled 1564 feet. The drilling encountered granitic rocks with subordinate diorite (AFRO, Toronto). Subordinate aplite dikes and a undefined dike rock are also present. Scattered sulphides are present in some holes but the mineralization appears minor. Assay values were not reported (AFRO, Toronto).

BIAGINI GROUP (25)

This 24 claim group is located in the southwest corner of Esquega Township and is also known as the Biagini-Calabani Group. The Claim Group

is drift covered. Self-potential and resistivity surveys were completed over the property and one diamond drill hole was recommended (AFRO, Toronto). No additional work was reported.

BLACKSMITH VEIN (26A)

The Blacksmith Vein occurs in the centre of Esquega Township along the contact between greenstone and a quartz-feldspar intrusion. This vein was not visited during the present survey.

ATNEL MINES LIMITED

The Blacksmith vein was examined by Hesse (1934, p.8, 9) for Atnel Mines Limited. The vein strikes at approximately 60° and varies from two to eight feet in width. It consists of white quartz with little mineralization (Hesse 1934, p.8). Holbrooke (1936, p.1) described the vein as 2 to 5 feet in width, striking at 65° dipping 50°S and occurring along a sheared contact of quartz porphyry and greenstone. He reported that the vein has a strike length of 570 feet. Holbrooke (1936, p.3) described the vein as consisting of massive white quartz weakly mineralized with pyrite.

ERIE CANADIAN MINES LIMITED

Erie Canadian Mines Limited completed an extensive program of channel sampling of the Blacksmith Vein. With the exception of several assays of 0.10 ounces Au per ton nearly all the remaining assays ran trace gold (AFRO, Toronto). Mapping by Erie Canadian Mines Limited indicated a strike length of approximately 750 feet.

J.Q. RESOURCES LIMITED 26A AND 26B (26-B)

In 1983 to 1984, the Blacksmith Vein was resampled by J.Q. Resources Limited and returned values less than 0.001 ounces Au per ton. The results support the earlier values by Erie Canadian Mines Limited. At Reed Lake (local name), the interpreted northeastern extension of the Blacksmith Vein was sampled (location 26B). Chip sampling returned values less than 0.06 ounces Au per ton and one grab sample returned 0.36 ounces Au per ton (AFRO, Toronto). The company completed one diamond drill hole (JQ 83-1) on the interpreted extension of the vein on the east side of Reed Lake. This drill hole totalled 190 feet and from 57.5 to 61.0 feet ran 0.16 ounces Au per ton (AFRO, Toronto). The gold-bearing material was described as quartz-carbonate vein material with disseminated pyrite, pyrrhotite and chalcopyrite. Four samples collected by the field party, from the vein exposed at surface returned only a trace of gold (Geoscience Laboratories, Ontario Geological Survey).

A second drill hole (JQ 83-2) was completed on the west side of Reed Lake (local name) to a depth of 150 feet on the Black Smith vein (AFRO). The drill log indicates mafic and felsic metavolcanic rocks and metasedimentary rocks were encountered. The best gold assay was 0.05 ounces per ton from 114 to 115 feet within a unit logged as metasedimentary rock (AFRO).

BUKELL COPPER SHOWING (27)

The existence of this showing was brought to the attention of the author by F. Archibald, consulting geologist, Toronto. A report was originally prepared on this showing by D.S. Baird (1943). The showing was relocated in 1981 by the field party. It consists of pyrite, chalcopyrite and traces of galena in fractured quartz feldspar porphyry and schistose mafic metavolcanic rocks marginal to a diabase dike. The diabase is weakly to moderately chloritized. The showing occurs on former claim AC 4535 and is referred to as the Joseph Bukell showing. The date of discovery is unknown. The showing had been trenched but most of the trenches are now overgrown. Additional work has not been reported. Baird (1943, p.2) reported an assay value of 2.69% Cu over 22 feet with 0.005 to 0.01 ounces per ton field party.

Table 21 presents assays on grab samples collected by the field party and Figure 77 gives the location of the samples.

FALCONBRIDGE LIMITED (28)

Falconbridge Limited completed an airborne Dighem III survey over 57 claims in 1983. The claims covered a large part of the western edge of Esquega Township. The survey was completed at a scale of 1:10 000 and included resistivity, enhanced magnetic, magnetic and electromagnetic components. A number of airborne anomalies were indicated but no follow up work was completed and the property was dropped.

FIRESPUR EXPLORATION LIMITED (FORMALLY LAKEMOUNT MINES LIMITED) (29-A)

The Firespur Explorations Limited property has had a long history of exploration and development. The most promising mineralization is hosted by the pyroxenite to peridotite intrusion centered on Sunrise and Elbow Lakes. This intrusion is approximately 2140 m long and 305 m wide. The long axis has a strike of approximately 290° which is approximately perpendicular to the strike of the enclosing metavolcanic rocks. On the basis of limited facing data the volcanic stratigraphy faces northwest and dips vertically to subvertically. The peridotite intrusion can not be traced eastward much beyond Elbow Lake and does not appear to extend above the intermediate to felsic metavolcanic rocks of subcycle one at the west end of Sunrise Lake. The east end of the intrusion appears more highly metamorphosed than the west end (thin section study). The metamorphic mineral assemblage is essentially talc, serpentine, chlorite, magnetite and actinolite with rare relict pyroxene and olivine. Moore (1946, p.120) reported the presence of scapolite.

The body is elliptical in plan view. If it had been emplaced before tilting of the supracrustal rocks into a subvertical position, the concentration of the sulphides at the east end would be at the bottom of the intrusion.

The main area of mineralization is known as the "F" Vein or "F" Zone and occurs close to the south contact of the peridotite body with the supracrustal rocks.

The sulphide mineralization is disseminated. The main "F" Zone has

been faulted into east and west segments (Johnston 1956, p.1). Johnston (1956, p.4) concluded from his evaluation of the exploration data that the mineralized portion of the peridotite body dips north and plunges to the west, however, Moore (1946, p.121) states the zone dips south at 40 to 45°. Martin (1953, p.3) indicated that the mineralization occurs in the coarse-grained peridotite and not in chilled marginal contact rock. The north contact of the ore zone has been described as gradational into low grade or barren peridotite and the southern contact as sharp (Robinson 1952, p.1). The sulphides generally stop at the contact with the supracrustal rocks but Robinson (1952, p.1) indicated sulphide mineralization will on occasion extend into the wall rock for several feet. Simard (1952, p.6) suggested that the mineralization is related to the contact zone. Macombe (1952, p.8) suggested that 3 other mineralized zones lie in the peridotite and Metcalf (1953, p.1) suggested as many as 7 zones, 20 to 30 feet wide averaging 0.35% Cu and 0.35% Ni may be present. Macombe (1951, p.5, 6) indicated that the east section of the mineralized zone dips approximately 70°N and the west section dips approximately 80°N. Deep drilling by New Kelore Mines Limited in 1956 is reported by Johnstone (1957, p.1) to have traced the westerly plunging mineralized zone to depths below 1000 feet. McGregor (1968, p.5) has interpreted a complex fold pattern to exist in the peridotite. His interpretation is based on a reinterpretation of diamond drilling. The mineralization was reported by Macombe (1952, p.4, 5) to consist of pyrrhotite, pentlandite, chalcopyrite and violarite. He reported the presence of Au, Ag, Pt and Pd in the sulphides.

Moore (1946, p.121) failed to find gold, silver or platinum group elements in samples collected by him.

Two grab samples of mineralized material exposed in a trench at the southeast corner of Elbow Lake were collected by the field party. The first sample returned 8520 ppm Cu, 8700 ppm Ni and 390 ppb Pt (Geoscience Laboratories, Ontario Geological Survey). The second sample returned 5220 ppm Cu, 8300 ppm Ni and 410 ppb Pt. Assays therefore confirm the presence, though minor, of platinum in the Sunrise Lake Peridotite.

A number of mineralized zones occur on the Firespur Exploration Limited property. These mineralized showings are invariably referred to as veins in early reports. Some are true veins or do have veins associated with the showing. Early reports numbered the showings. Starting with Mather (1939a, 1939b), however, the showings were given letters or numbers which have been retained in all subsequent reports written on the property. The field party briefly examined three of these old showings at the time they were being examined by Firespur Exploration Limited.

NUMBER 1 VEIN (29B)

The No.1 Vein occurs in the southeast corner of the property and was probably the first mineralization found. Summerhayes (1928, p.5) reported that a chip sample along the vein returned 0.54 ounces Au per ton and 13.2% Cu. He identified chalcopyrite, bornite, galena and sphalerite. He described the vein as 12 to 24 inches wide, striking 30°, dipping vertical and traceable for 1200 feet. In 1928, Allen (1928) reported on 9 channel samples taken on the No.1 Vein. These values are tabulated in Table 22.

Mather (1939b, p.2) reported that the vein strikes 35|, dips from vertical to 45|, varies from 22 to 4 feet in width and is traceable for 600 feet. Mather (1939b, p.3) reported pyrrhotite and native copper in the vein. The native copper, if truly present is likely a weathering product of the chalcopyrite.

Baird (1943?) described the vein as a brecciated zone with quartz filling which can be traced for 800 feet. He mentions the presence of silver and that 3 short diamond drill holes had been drilled into the showings. Baird (1943?) states the zone is shallow dipping to the southeast. No records for the drilling could be located.

In 1980, Firespur Explorations Limited completed one diamond drill hole (80-1) totalling 401 feet. A siliceous section from 155.5 to 167.5 feet contains disseminated pyrite and chalcopyrite. This section is reported by the company to contain trace to 0.01 ounces Au per ton, 0.06 to 0.08 ounces per ton Ag and 0.012 to 0.18% Cu.

A brief visit by the field party to one of the filled trenches identified a silicified shear zone dipping southeast at 40 to 45| and striking approximately 30|. The showing occurs on or beside the regional Hawk Lake Manitowik Lake Fault. One grab sample collected by the field party (SP1 1-1) returned 2.51% Cu, 400 ppm Zn, 0.02 ounces Au per ton and 0.66 ounces Ag per ton. The location of the samples is indicated on Figure 78.

VEIN A

Mather (1939a, p.3) described this showing as a mineralized quartz vein 18 inches wide striking 60| and dipping steeply south. The type of mineralization was not mentioned, the location is not precise and no attempt was made by the field party to locate this vein.

VEINS B, C AND H (29C)

The B, C and H veins are most likely one vein exposed in three different areas. (Mather 1939a, p.3). Mather (1939a, p.3) described the vein system as varying from 1 to 10 feet in width, striking 15 to 25| and dipping vertically to 45| east. Baird (1943?, p.6) reported the vein to be up to 25 feet wide. The vein is described as being hosted by brecciated, sheared and silicified greenstone (Mather 1939a, p.3, 4; Baird 1943?, p.6, 7). McGregor (1968, p.7) estimated this vein system to be 1000 feet long. One exposure was visited and sampled by the author in the presence of F. Archibald (Firespur Explorations Limited). The showing consists of weathered, pyrite-bearing, sheared mafic metavolcanic rocks with an irregular milky quartz vein containing galena and sphalerite. The mineralized quartz vein (FSP-4, 3) returned 7.15% Zn and 6400 ppm Pb, with a trace of Au and Ag. The sheared pyrite-bearing greenstone returned only a trace of gold (Geoscience Laboratories, Ontario Geological Survey). The sample location are given in Figure 76.

VEIN D

This vein is located in the northwestern part of the property and is described by Mather (1939a, p.4) as being up to 3 feet wide, striking 90|

dipping 60°N and occurring along the contact of greenstone with quartz-feldspar porphyry. Mineralization is reported to consist of galena, sphalerite, chalcopyrite, pyrrhotite, pyrite and arsenopyrite. This vein was not prospected by Firespur Explorations Limited and its precise location is uncertain. This reported vein was not located by the field party.

VEIN E (29D)

Vein E is one of the more interesting mineral showings observed in the Wawa area. It is a silicified zone along the contact between mafic metavolcanic rocks and quartz-feldspar porphyry. The mineralization strikes north, dips 80°W and has a width of approximately 3.0 feet. Excellent mineralization consisting of galena, sphalerite, chalcopyrite and pyrite is present. Mather (1939a, p.4) reported the presence of pyrrhotite and arsenopyrite which could not be verified by the author. Baird (1943a, p.7) reported that a diamond drill hole was drilled below the showing but failed to intersect mineralization.

Firespur Exploration Limited completed two diamond drill holes (80-5, 80-6) from opposite directions which also failed to intersect mineralization. This drilling totalled 491 feet. The mineralization appears to be a small lense with no appreciable depth extension along the quartz-feldspar porphyry-mafic metavolcanic contact.

One grab sample collected by the field party from the trench returned 1.83% Cu, 8.80% Zn, 0.01 ounces Au per ton and 6.53 ounces Ag per ton. The location of the sample is given on Figure 76.

VEIN F (29A)

Vein F is the Sunrise Lake Copper-Nickel showing and has been discussed above.

VEIN G

Vein G is described as a quartz vein situated along the contact of a quartz-feldspar porphyry intrusion and mafic metavolcanic rocks. It is situated (0.6 km) southeast of the peridotite intrusion centered on Sunrise Lake (Mather 1939a, p.4). He described the mineralization as being chalcopyrite. The location of this vein is unknown and it was not relocated during the present survey.

VEIN J (29E)

Vein J is locally referred to as the "Old Lead Pit" and is located in the south-central part of the property. The vein is described by Mather (1939a, p.4) as a silicified zone two feet wide along a quartz-feldspar porphyry-mafic metavolcanic contact.

The mineralization is described as galena, chalcopyrite, sphalerite and pyrite. The contact is described as striking north with a vertical to slightly west dip (Mather 1939a, p.4). This vein was relocated by the field party but little information could be gathered from the covered and filled pits and trenches. Grab samples collected by the field party from

the pit disclosed mostly chalcopyrite and pyrite mineralization. E. Frey, District Geologist, Wawa did find galena at the site in 1984 (personal communication 1984). Three grab samples collected in 1980 by the field party returned 318 to 5200 ppm Cu and 166 to 212 ppm Zn. Gold was not assayed for. McGregor (1968, p.7) reported Au to be present in quantities of 0.01 ounces per ton.

Mather (1939a, p.2) reported two showings of molybdenite on the property. One showing is described as molybdenite and chalcopyrite along minute fractures in silicified porphyry next to a lamprophyre dike. The second showing is described as small crystals of molybdenite and chalcopyrite in minute quartz stringers cutting porphyry. The showings were relocated by Firespur Explorations Limited and one was examined by the field party. Molybdenite could not be found at either site.

Macauley (1962c, p.4) indicated the presence of asbestos in a outcrop at the east end of Elbow Lake. This was not located by the survey but is described by him as hard chrysotile and not true soft asbestos fibre.

The history of this property is involved and gaps exist in the documented series of events. It is unclear from the existing reports just when certain property transfers took place. The history as outlined here is subject to modification if some of the missing records reappear.

J. H. Teare staked a copper and gold showing on the property in 1926 (Gledhill 1927, p.45; MacLeod 1934, p.1). The original discovery was probably the No.1 Vein. The property was known as the Andargo Group at that time (Gledhill 1937, p.45); MacLeod 1934, p.1). Gledhill (1927, p.45) reported that the property was optioned to the Conigas Mining Company, however, the author could find no record of work by this company on the property.

In 1927, R. Bond applied to the Algoma Central Lands Department for an area of 12 square miles (Moore 1943?, p.1). After prospecting this ground, he decided on a 3 square mile area that was transferred to him in 1929 and which became known as the Engineers Holding Company Limited property (MacLeod 1934, p.1; Moore 1943?, p.1). This property was apparently never registered in the name of the company (Moore 1943?, p.1; MacLeod 1934, p.1). The parcel (No. 2017) is under a 99 year lease from the Algoma Central Railroad. The history of the property is condensed from records provided by many exploration companies and individuals. R. Renaldi, present owner of the property, has been generous in providing old records on the property.

ENGINEERS HOLDING COMPANY

The Andargo Group (sometimes referred to as the Bond Location) was probably transferred to the Engineers Holding Company Limited (even though never registered in the name of the company) in about 1929 after the property grant to R. Bond. The property was regarded as dominantly a gold and copper property and Summerhayes (1928) Allen (1928) and MacLeod (1934) all prepared reported on it. D.S. Baird also prepared an undated report on the property for the company. The author has been unable to resolve the 1929 date of property transfer to R. Bond and the 1928 dates on the Summerhayes and Allen reported indicating it was already under control of Engineers Holding Company Limited. The Engineers Holding Company Limited completed trenching on many surface showings and is

reported to have trenched the copper-nickel bearing peridotite intrusion at Elbow Lake in 1934 (Moore 1946, p.120). Exactly when, or by whom, the copper-nickel mineralization was found apparently was never recorded. A report accompanying the report by McGregor (1968) indicated that R. Bond had a mill test completed for copper and nickel on a 'gabbro' sample in 1929. The report was for the Engineers Holding Company Limited and suggested that mineralization in the Sunrise Peridotite was known as early as 1929.

CORINTH MINES LIMITED

The precise date of transfer of the property from Engineers Holding Company Limited is unknown however Mather (1939a, 1939b) prepared reports on the property for Corinth Mines Limited in 1939 and the author assumes the transfer of the property occurred shortly before that time. There is no record of work being completed on the property by the company. Mather (1939a) completed a geological sketch map of the property for the company (AFRO, Toronto).

SYLVANITE GOLD MINES LIMITED

Sylvanite Gold Mines Limited prepared a sketch map of the property in 1940 while it was owned by Corinth Mines Limited. There is no record of further work by Sylvanite Gold Mines Limited.

LAKEMOUNT MINES LIMITED

In approximately 1942, the property was transferred or control gained by the Lakemount Prospecting Syndicate. McCombie (1952, p.2) states the property was purchased from R. M. Bond in 1942 by Lakemount Mines Limited. He did not mention what happened to Corinth Mines Limited nor did he acknowledge that Lakemount Mines Limited was not incorporated until 1943. Corinth Mines Limited received 183,333 shares and Lakemount Prospecting Syndicate received 150,000 (Canadian Mines Handbook 1944, p.100). The Lakemount Prospecting Syndicate began surface X-ray diamond drilling as well as standard diamond drilling on the Sunrise Lake peridotite intrusion.

Lakemount Mines Limited continued with surface diamond drilling started by the Lakemount Prospecting Syndicate. This work continued up to 1944. In early 1944 Hans Lundberg Limited completed a magnetic survey of the Sunrise Lake peridotite.

N.A. TIMMINS LIMITED

The property was optioned by N.A. Timmins Limited from Lakemount Mines Limited in mid-1944. They continued the surface drilling program. N.A. Timmins Limited dropped the option in 1945 (McCombe 1952, p.3).

KELORE MINES LIMITED

No further work was recorded on the property until the property was optioned by Kelore Mines Limited in early 1951 (McCombe 1952, p.3). This

company continued with surface drilling and contracted concentration tests to Lakefield Research Limited. The concentration tests were favourable indicating a good recovery and relatively easy grinding (Lakefield Research Limited 1952, p.1, 2). In 1953, Kelore Mines Limited became New Kelore Mines Limited (Canadian Mines Handbook 1953, p.142).

VENTURES LIMITED

In 1953, Ventures Limited optioned the property from New Kelore Mines Limited and completed a surface diamond drill program. Ventures Limited terminated their interest in late 1953 (Johnston 1956, p.1) and the property reverted back to New Kelore Mines Limited.

NEW KELORE MINES LIMITED

From 1956 to 1957, New Kelore Mines Limited conducted a deep diamond drill program which established the fact that the mineralization plunges west and extends to a depth exceeding 1000 feet (Johnston 1957, p.1). Prior to the drilling the company completed self potential surveys over select areas of the property and an electromagnetic survey over the peridotite at Sunrise Lake. New Kelore Mines Limited dropped their option in 1957 and the property reverted to Lakemount Mines Limited (Belyea ?).

Lakemount Mines Limited completed 5 diamond drill holes totalling 1018 feet of diamond drilling in 1960 (Canadian Mines Handbook 1961, p.132). Two holes were completed on the Number 1 Vein and three others on geophysically indicated conductors within the metavolcanic rocks enclosing the Sunrise Lake peridotite. Brown (1958), for the Anaconda Company, Hodder (1959), for the Southwest Potash Corporation and McGregor (1968) for Amax Exploration Limited completed evaluations of the property for their respective companies. The property was not optioned by the above three companies. Additional work by Lakemount Mines Limited has not been reported.

ALGOMA ORE PROPERTIES LIMITED

While remaining under control of Lakemount Mines Limited, Algoma Ore Properties Limited completed geological mapping and a electromagnetic survey over the Sunrise Lake peridotite (Macauley 1962c). This work was completed in part to determine geological relationships and test the geophysical response of the mineralization so that the information could be applied to other ground held by the company in the area. The electromagnetic survey did not pick up the sulphide mineralization (Wagner 1962c). The geological map by Macauley (1962c) is the first outcrop map prepared on the property that could be located by the author. Algoma Ore Properties Limited have completed no additional work on the property.

SELCO EXPLORATION COMPANY LIMITED

Selco Exploration Company Limited optioned the Lakemount property in 1967 and completed airborne magnetic and electromagnetic surveys over the

property. The magnetic survey indicated a magnetic high over the Sunrise Lake peridotite and the electromagnetic survey indicated the presence of one conductor at the southeast end of Bremner Lake. The company completed no additional work on the property.

SHIELD DEVELOPMENT COMPANY

The Shield Development Company optioned the property in 1969 (Northern Miner July 17 1969) from Lakemount Mines Limited. There is no record of work being completed by this company.

FIRESPUR EXPLORATION LIMITED

In 1978, Firespur Explorations Limited purchased the Lakemount Mines Limited property. The company cut a grid over the property and completed a geological map, electromagnetic and magnetic surveys. In 1980 and 1982 the company examined the "E" Vein, No.1 Vein and B, C and H Vein. Stripping and diamond drilling were completed by the company on the "E" Vein, No.1 Vein and Sunrise Lake peridotite. The property is currently being maintained by the company.

The Sunrise Lake peridotite has had a lengthy and involved history of exploration with nearly all the effort being concentrated on the copper-nickel mineralization in the peridotite. The records for the early history of the property are sketchy and the large amount of diamond drilling completed in the 1940's is difficult to interpret due to lack of location and orientation data for the drill holes as well as inadequate rock descriptions. The drilling by Kelore Mines Limited and New Kelore Mines Limited and Ventures Limited is the most informative. The report by McGregor (1968) is the most informative report available to the author. The relatively low grade copper and nickel values will inhibit its development as a base metal producer in the near future, however additional work on this showing should pay close attention to the platinum group elements as existing data on the concentrations of these elements is incomplete. Figure 79 is a compilation of diamond drill hole and outcrop data for the Sunrise Lake peridotite. Table 23 is a tabulation of diamond drilling completed on the property and Table 24 is a tabulation of tonnage and grade figures calculated by many authors over the years.

Most of the other mineralized showings on the property suggest a relationship of mineralization to quartz-feldspar porphyry-mafic metavolcanic contacts. The mineralization is locally spectacular but work completed so far has failed to develop significant reserves.

JALORE MINING COMPANY LIMITED (51) (SEE JUDITH IRON RANGE, MCMURRAY TOWNSHIP) KATHLEEN IRON RANGE (30)

The Kathleen Iron Range (also known as Macauley Iron prospect) occurs east of the north end of Loonskin Lake. The range strikes northeast near the lake but swings to the east as one moves east. The iron formation appears to have a subvertical dip and faces northwest. The iron formation caps a thin unit of intermediate to felsic metavolcanic rocks

of subcycle one. The underlying felsic metavolcanic rocks are tuffs, lapilli tuff and rare breccia and quartz feldspar crystal tuff. The underlying felsic metavolcanic rocks are intercalated with mafic tuffs. The overlying rocks are mafic tuffs, commonly with tiny bluish quartz grains and massive to pillowed mafic metavolcanic rocks. Locally, the mafic tuff is thin bedded. The iron formation consists of granular chert and pyrite. The pyrite occurs near the bottom of the unit. The iron formation is up to 30 m wide and has an estimated strike length of 1433 m. The iron formation pinches and swells along strike and gaps may exist in the unit. The Kathleen Iron Range is likely correlative with small segments of iron formation located immediately east of the south east side of Loonskin Lake (Collins and Quirke 1926, p.92). These small iron formation units have been investigated by Algoma Ore Properties Limited (AFRO, Toronto). The Kathleen Iron Range occurs at the same stratigraphic position as the Judith Iron Range in McMurray Township. The Judith and Kathleen Iron Ranges may represent a once continuous iron formation unit that has been segmented during deformation. Relative to the main Michipicoten Iron Range that is situated stratigraphically above the Kathleen Iron Range, the underlying intermediate to felsic metavolcanic section is thinner and displays fewer rock types. Mapping by Algoma Ore Properties Limited indicate that siderite is present in the range (AFRO, Toronto). Siderite was not found on this iron range during mapping.

The early history of the property has not been recorded. Huddart (1961, p.1) indicated the claims were staked 30 to 40 years prior to 1961 and that pitting and trenching had been completed. The original claims lapsed in about 1959 and they were restaked by a F. Macauley who was part of a consortium (Huddart 1961, p.1). The claims were probably optioned from Mr. Macauley and his consortium by Algoma Ore Properties Limited in 1961.

ALGOMA ORE PROPERTIES LIMITED

In 1961, Algoma Ore Properties Limited completed dip needle geological mapping, magnetometer and electromagnetic surveys over the property (Huddart 1961, p.1, 2; Hough 1961). There is no record of additional work.

MURRAY ALGOMA GOLD OCCURRENCE (31)

The Murray Algoma Mining Company Limited occurrence is located at the north contact of a quartz porphyry intrusion at the north end of Reed Lake. At the east end of the showing, the rocks are probably sheared intermediate to felsic metavolcanic rocks, however, at the west end trenching disclosed sheared, carbonated and silicified mafic intrusive rocks. Disseminated pyrite is present and rarely a speck of visible gold and traces of chalcopyrite can be found. The zone strikes east and varies from 5 to 6 feet wide. On the basis of the old trenches, the mineralized zone exceeds 41 m in strike length. The dip appears to be vertical or slightly north. The Murray Algoma gold occurrence is located at the same stratigraphic position and within a similar geologic setting as the Atnel gold occurrence to the west. Studemeister (1984, p.10) interpreted the rocks at the showing to be tuffs. He reported that the

gold occurs both in the tuffs and in quartz veins with associated pyrite, tourmaline, pyrrhotite and traces of chalcopyrite.

Quartz crystal tuffs and intermediate to felsic lapilli tuffs were mapped by the field party in the area northwest of the occurrence.

Moore (1931, p.41) described a gold discovery on claim 2301 in Esquega Township that is likely the same occurrence as the Murray Algoma gold occurrence. At the time of his visit the showing was freshly exposed. He described the showing as quartz veins striking 72° in a sheared greenstone. The dip was observed by him to vary between 45 and 60°S and the shear had a width of 4 feet (Moore 1931, p.41).

Grab samples were collected from the trenches by the field party and the assay results given in Table 25. The location of the samples is indicated on Figure 80. Table 26 and Figure 81 give the location and results obtained by Murray Algoma Mining Company Limited.

The original discovery of gold on the property was made by R. Patterson in 1928. He subsequently sold his claim (s) to W.H. Reed of Hawk Junction (Lamb 1938, p.16). The original gold find was on claim 2301 at the north end of a small lake now locally referred to as Reed Lake.

In 1930, the property was optioned to a R.N. Bond who completed stripping and trenching (Hopkins 1930, p.2). Hopkins (1930) prepared a geological map of the property. The property reverted back to R. Patterson and in 1933 Orecana Trust of Chicago was granted an option on the property but there is no record of work by the company on the property. In January 1934, the property was purchased by Murray Algoma Mining Company Limited.

MURRAY ALGOMA MINING COMPANY LIMITED

In 1934, the company conducted surface prospecting and let a contract for 1500 feet of diamond drilling which resulted in 13 holes the deepest of which did not exceed 210 feet (Lamb 1938, p.17). Records for this drilling could not be located. In 1935, the company completed metallurgical testing, surface sampling and started construction of a Mill (Lamb 1935, p.17). Mill construction and additional trenching was completed in 1936 and in 1937 a 500 ton bulk sample was taken from surface and ran through the mill (Lamb 1938, p.18). Additional metallurgical tests were completed during 1937 at the University of Toronto, Department of Engineering and Metallurgy (Lamb 1938, p.33). The rotted remains of the mill were still at the site in 1980.

The mill test is reported to have returned values of \$6.00 per ton or an estimated 0.17 ounces Au per ton (\$35.00 per ounce; Lamb 1938, p.18). An estimated 6,000 tons grading 0.43 ounces per ton remain (Canadian Mines Handbook 1938, p.193). Murray Algoma Mines Limited took over Murray Algoma Mining Company Limited in 1938 and attempted to reactivate the property (Canadian Mines Handbook 1939, p.184). There is no record of additional work. The charter of Murray Algoma Mines Limited was cancelled in 1956 (Canadian Mines Register, p.266).

J-Q RESOURCES LIMITED

The property of the former Murray Algoma Mines Limited was staked by J-Q Resources Limited in 1981. The company completed radiometric and VLF

electromagnetic surveys over the property in 1983. Channel samples taken in the old trenches in 1983 indicated values ranging from 0.01 to 1.25 ounces Au per ton (Studemeister 1983). Studemeister (1983, p.11) indicated one sample returned 0.86 ounces per ton over a width of 2.3 m. The sampling indicated highly erratic gold values. The company completed no additional work on the property and it was dropped in 1984.

PANGO GOLD MINES LIMITED (32)

Pango Gold Mines Limited staked 15 contiguous claims in the southwest corner of Esquega Township in 1970. A grid was cut over parts of the claim group and a ground magnetometer survey completed. No further work was done and the claims were dropped.

REGNERY METALS MOLYBDENITE OCCURRENCE (33)

In the southeastern corner of Esquega Township a property formerly owned by Regnery Metals Limited has undergone considerable investigation for its molybdenum, copper and beryllium potential. The workings occur in a light pink medium to coarse-grained granodiorite to quartz monzonite phase of the Hawk Lake Granitic Complex. The rock is equigranular massive and lacks a well developed foliation or lineation. Moving north and west from the showing the granitic rocks become increasingly porphyritic. Quartz phenocrysts with a faint bluish opalescence may develop and the more distant phases are a typical quartz feldspar porphyry. Feldspar phenocrysts are not as prominent as the quartz phenocrysts.

Examination of the muck pile at the former Regnery Metals Limited mine site indicates dominantly granitic rock with subordinate quantities of fine-grained mafic rock. These rocks are noticeable by their lack of structure and alteration. The fine-grained mafic rock has been mapped as anastomosing lamprophyre intrusions on plan maps of the first level of the mine (AFRO, Toronto). Lamprophyre does not outcrop at or near the mine. The lamprophyre dikes on the plan map of the Regnery Mine trend north unlike other lamprophyre dikes of the area mapped by the field party, that display a strong northeast strike conformable with faulting and fracturing trends of the Kapuskasing Structural Zone. While the dikes may be true lamprophyre, on the basis of mapping in the area by the field party, the mafic rocks mapped as lamprophyre may be in part a dismembered and altered screen of mafic metavolcanic rocks engulfed within the intruding granitic rocks.

Molybdenite can be found on the muck pile at the mine site but it is not abundant. It occurs dominantly as tiny grains 1 mm or less in diameter along fractures in the mafic rock and to a lesser degree along fractures in the granitic rock marginal to the mafic rock. Traces of pyrite and chalcopyrite are sometimes associated with the molybdenite. Bruce (1938, p.2) reported that the molybdenite is very fine-grained and occurs along fractures in the granitic rock. Chalcopyrite was observed by him to occur in masses up to two or three pounds in weight in fractures within the granitic rock (Bruce 1938). Chalcopyrite mineralization was described by him as erratic. A plan map of the first level indicates mineralization occurs in small masses at the point where

the lamprophyre branches or splits.

In contrast to the largely barren dump material near the old mine site a small number of high grade samples of sulphide were located by the field party near the top of the old shaft. This material consists of very coarse-grained chalcopyrite and pyrite with granular quartz. Some specimens contain an estimated 1 to 2% fine-grained molybdenite. The source of this material is unknown and the association of molybdenite with base metal mineralization is not known to occur elsewhere in the Wawa area. The granular quartz with associated chlorite in some samples may be recrystallized chert and the coarse-grain size of the sulphides could be the result of recrystallization due to contact metamorphic effects due to the intruding granitic rocks.

Tentatively the author suggests that the mafic rocks and contained mineralization found at the former mine site may represent recrystallized mafic metavolcanic and iron formation xenoliths and blocks in the granitic complex. The mineralization is thus spatially related to the lower part of the supracrustal sequence of subcycle one and not to the granitic rocks. This would imply that only small discontinuous blocks containing mineralization are likely to be present.

Early reports referred to by other authors on the property suggests the presence of beryllium. These reports are unavailable to the author but were instrumental in International Ranwick Limited completing an underground examination of the property (Wagner 1958?). From the muck pile at the mine site the author selected 2 samples of the mafic rock and 6 samples of the granitic rock for the determination of their beryllium content. The mafic rocks returned 1 to 2 ppm and the granitic rock 2 to 3 ppm beryllium (Geoscience Laboratories, Ontario Geological Survey).

The beryllium values are typical of Archean rocks in general and there is no evidence that beryllium is anomalous in the rocks found at the former mine site. Two grab samples of the high-grade sulphide mineralization found at the top of the shaft were analyzed. Sample Reg - HG-1 returned trace gold, 8.275% Cu and 205 ppm molybdenum. Sample Reg - HG-2 returned 0.01 ounces of Au per ton, 13.25% Cu and 730 ppm molybdenum. Assays were by the Geoscience Laboratories, Ontario Geological Survey.

The original discovery of mineralization on the property was made by W. Regnery in 1936 (Northern Mines files 1937). The property was owned and operated by Mr. Regnery and his partners from 1937 to 1940 (MDIR, Toronto).

REGNERY METALS LIMITED

Regnery Metals Limited completed a geophysical survey on the property in 1937 (unavailable) and shaft sinking started (MDIR, files, Toronto). An inclined shaft at 45° was sunk to 243 feet and levels established at 92 and 230 feet. An adit 440 feet southeast of the shaft connects with the first level, however, no record could be found as to when it was driven. Seven diamond drill holes were completed from surface totalling 1821 feet and 15 holes from underground totalling 1487 feet (AFRO, Toronto). Other statements (AFRO, Toronto) suggest as much as 8000 feet of diamond drilling has been completed on the property. No record of this drilling could be located.

Reserves were estimated to be 170,000 tons to 300 feet averaging 1.1% MoS₂ (MDIR, Toronto).

A small sampling plant was set up in 1939 and values of 0.05 to 0.25% MoS₂ were reported (MDIR, Toronto). A 400 ton bulk sample was run through the mill in 1940 producing a concentrate of 65 to 70% MoS₂ and 2.0% Cu (MDIR, Toronto). The concentrate was reportedly upgraded before the mill was dismantled in 1940 (MDIR, Toronto).

INTERNATIONAL RANWICK LIMITED

International Ranwick Limited optioned the property in 1958 from Regnery Metals Limited. The company dewatered the shaft, sampled the first level and completed 532 feet of diamond drilling from the second level (Wagner 1958?, p.3). The company estimated the reserves to be 13,000 tons grading 0.11% Mo over a width of 3.8 feet and a height of 100 feet (Wagner 1958?, p.5). The various veins varied from 0.08 to 0.16% Mo (Wagner 1958?). Significant beryllium values were not encountered by the company. It appears that both the molybdenum and beryllium assays reported by Regnery Metals Limited were in error due to a problem with assaying techniques (Riley 1958). The work by International Renwick Limited has effectively eliminated the property as a potential molybdenum or beryllium producer. The company may have terminated its option in late 1958.

RUTH IRON RANGE (34)

The Ruth Iron Range is bounded by the Bauldry Lake Fault on the west and the Goetz Lake Fault on the east. This iron range strikes northeast, has a subvertical dip, faces northwest and separates first and second cycle volcanism. The iron range is cut in several places by low angle oblique faults which locally greatly thin the iron range. At the Lucy Iron Range 1000 m of second cycle intermediate to mafic metavolcanic rocks overlies the iron range. At the Ruth Iron Range, however, low angle oblique faults have faulted out the intermediate to mafic metavolcanic rocks and clastic metasedimentary rocks lie in direct contact with the iron range.

The Ruth Iron Range is the faulted eastern extension of the Lucy Iron Range. The Goetz Lake Fault offsets the eastern extension of the Ruth Iron Range into Corbiere Township where it becomes the Josephine Iron Range. The Ruth Iron Range has a strike length of approximately 1830 m and a width of approximately 91 m in the least faulted area. Moore and Armstrong (1946, p.66) states that a syncline enters the area of the Ruth Iron Range at the southwest end of Cuthbertson Lake and a southwest pitching anticline occurs within the iron formation. Mapping by the writer did not confirm these fold structures. Moore and Armstrong (1946, p.66) reported a fault along Cuthbertson Creek. This fault was confirmed by the author and is considered to be part of the Magpie River fault system.

The Ruth Iron Range was staked by A. Goetz in 1899 (Moore and Armstrong 1946, p.59) and has passed through nearly the same corporate history as the Lucy Iron Range. As a consequence of its close relationship with the Lucy Iron Range, records for work on both iron ranges are often mixed.

Trenching and surface prospecting on the Ruth Iron Range took place sometime after 1899 (Moore and Armstrong 1946, p.59).

BETHLEHEM STEEL CORPORATION

In 1930, the property was optioned by Bethlehem Steel Corporation who completed an adit and 8 diamond drill holes (Moore and Armstrong 1946, p.59). Mapping along the range by the field party could not locate the adit and it is presumed to have been filled.

MICHIPICOTEN IRON MINES LIMITED

In 1941, the Ruth Iron Range was purchased from A. Goetz by Frobisher Exploration Company Limited. The property became known as Michipicoten Iron Mines after 1942 (Moore and Armstrong 1946; MDIR, Toronto). Michipicoten Iron Mines is presently controlled by Sherritt Gordon Mines Limited who control 67% of the company (Canadian Mines Handbook 1984, p.238). Michipicoten Iron Mines completed a major surface diamond drill program on the property in 1942.

JALORE MINING COMPANY LIMITED

In 1947, the Jalore Mining Company Limited optioned the property from Sherritt Gordon Mines Limited. The Jalore Mining Company Limited completed additional drilling, geological mapping, gravity, electromagnetic and self potential surveys. Jalore Mining Company Limited exercised the option in 1949 and took out a 50 year lease on the property (Hames and Gallie 1956, p.2). The company terminated its option in 1955. Richter (1952, p.35) worked for the Jalore Mining Company Limited and described the Ruth Iron Range as 400 feet thick, broken into 3 segments by faulting and having a strike length of 3800 feet.

ALGOMA STEEL CORPORATION LIMITED

In 1967, the Algoma Steel Corporation Limited optioned the property for 99 years from Michipicoten Iron Mines and proceeded with plans to develop the property (MDIR, Toronto). A series of short surface diamond drill holes were completed and a road constructed to the range. Work was terminated before production began. Hames and Gallie (1956, p.3) indicated the Ruth Iron Range has an open pit potential of 4,618,000 tons and an underground potential of 21,947,000 tons. Jarvis (1966, p.2) indicated open pit reserves at the Ruth are 2,066,000 tons in a west ore body and 923,000 tons in a east ore body. Table 27 gives the tabulated diamond drilling completed on the Ruth Iron Range and Figure 82 gives the location of the holes. The 1978 annual report of the Algoma Steel Corporation Limited indicates a reserve of 2,867,000 tons of unspecified grade in the Ruth Iron Range.

SOOCANA REED-BOOTH GOLD SHOWING (35)

The Soocana Mining Company Limited property in Esquega Township is known as the Soocana Reed-Booth gold showing. The original Soocana-

Reed-Booth gold showing consisted of 6 claims numbered 3041 to 3046 situated in the northeast corner of Esquega Township.

The Soocana-Reed-Booth gold showing occurs at the same general stratigraphic position and within the same geological environment as the Atnel and Murray Algoma gold occurrences showings. The showing occurs in a shear zone crossing the greenstone-quartz-feldspar porphyry contact. At the other showings, the shearing appears to be approximately conformable but on the Soocana-Reed-Booth property the shearing is oblique to the contacts. Sketch mapping of the showing by Sylvanite Gold Mines Limited suggests the contact is offset left-lateral, approximately 40 feet along the shear zone. This could not be confirmed by the field party due to inadequate exposure. Gledhill (1937b, p.8) described the vein as traceable for 75 feet on surface, has a width of 6 feet dips 60|E and strikes at 330|. The shear zone is referred to as the Shaft Vein.

Approximately 200 feet north of the Shaft Vein is located the Fissure Vein which strikes approximately normal to the Shaft Vein (Gledhill 1937b, p.9). This vein is solid milky quartz with traces of pyrite. The host rock is quartz-feldspar porphyry. The vein is traceable for 180 feet. A channel sample across 3.0 feet is reported to have returned 0.15 ounces of Au per ton.

Approximately 250 feet north of the Fissure Vein lies the Galena Vein (Gledhill 1937b, p.9). This vein strikes 155, dips 55|E and is approximately 1 foot wide. Gledhill (1937b, p.9) reported the vein to be 5 feet wide. This most northerly vein contains galena, pyrite and possibly some chalcopyrite. The vein cuts chlorite schist appears irregular in dip and width and could be traced for only 25 feet by the field party before disappearing beneath cover.

All three veins were found by the field party. The Shaft Vein is poorly exposed and previous strippings covered. The Fissure Vein is well exposed and appears to be relatively unmineralized. The Galena Vein is not well exposed but mineralized samples can be collected and examined. The Galena Vein could not be traced for any distance due to lack of exposure.

Table 28 gives the assay results for samples collected by the field party and Figure 83 gives their location.

Exactly when claims AC 3401 thru 3046 were staked and by whom, apparently was not recorded. Gledhill (1937b, p.4) reported gold was discovered in the area in the summer of 1934 by prospectors named Reed and Booth. Gledhill (1934, p.2), however, mentions the completion of stripping and sampling on the Soocana-Reed-Booth gold showing in early 1934 and in all probability this showing was found earlier. The Soocana Mining Company Limited was incorporated in November 1933 to take control of and undertake development of both the Reed-Booth and Holdsworth claim groups in adjacent Corbiere Township (Company Prospectus, AFRO, Toronto).

On the Shaft Vein (Reed-Booth No.1 Vein), an inclined shaft at 60| to the east was sunk to a depth of 17 feet (Gledhill 1937, p.5). On the basis of the amount of rock at surface the reported depth of 17 feet is likely the current depth of the shaft (Plate 39). Five diamond drill holes totalling 1360 feet were completed, however, it is doubtful that those drilled to test the shaft vein reached their target (Gledhill 1937b, p.5).

The company completed no additional work on the property and wound up

its operations in 1940 (Canadian Mines Register, p.362).

SYLVANITE GOLD MINES LIMITED

A brief examination of the property was made by Sylvanite Gold Mines Limited in 1940. No additional work was completed. The property has remained dormant up to the present.

LASTHEELS TOWNSHIP

ALDO PALMA MOLYBDENUM SHOWING (36) (FORMERLY PETER QUILTY PROPERTY)

The Aldo Palma Molybdenite showing is located in the north-central Lastheels Township near the Dill River. The showing is in the Hawk Lake Migmatitic Terrain close to the northern contact with the Whitefish Lake Batholith. The property was briefly examined by the author. A thesis on the property has also been completed by Skrecky (1981). Since Skrecky (1981) has spent a considerable period of time on the property, while employed for Amax Minerals Exploration Limited his observations, will be cited extensively and modified where warranted. The rocks at the showing consist of three early phases of trondhjemite, later more potassium-rich aplite and pegmatite dikes and blocks of mafic metavolcanic and possibly of metasedimentary rocks.

Trondhjemite is the dominant rock type with a coarse-grained phase being earliest, followed by a medium-grained phase and then a fine-grained phase. The medium-grained phase is the most abundant. The later potassium-rich phases may be related to the Whitefish Lake Batholith.

Skrecky (1981, p.5) reported that all three trondhjemite phases are composed of approximately 30% quartz, 65% plagioclase and 5% biotite. Skrecky (1981) in numerous petrographic descriptions reported that the plagioclase has an anorthite content of approximately 10%. As a consequence of the highly sodic nature of the plagioclase combined with a low colour index the author prefers to classify the rock as trondhjemite rather than as tonalite as did Skrecky (1981).

The coarse-grained trondhjemite has a weak schistosity due to alignment of biotite crystals. The other phases do not display an apparent foliation.

The fine-grained trondhjemite phase is higher in SiO₂ and lower in Al₂O₃, MgO and Fe₂O₃, than the coarser-grained phase (Skrecky 1981, p.12).

Within the granitic rocks are blocks of massive mafic metavolcanic rocks and schistose metasedimentary rocks. The metasedimentary rocks display a schistosity that is subparallel to compositional layering (bedding?) in the metasedimentary rocks. Skrecky (1981, p.6) reported that these blocks have been metamorphosed to the lower epidote-amphibolite rank.

The mineralized zone is approximately 875 m long with a long axis striking 50° (Skrecky 1981, p.6). Skrecky (1981b) reported the zone to be 50 to 200 m thick and dips north between 15 and 40°. The mineralized zone is subparallel to the greenstone-granite contact and subparallel to local lineaments. This trend is also parallel to the trend of the Hawk Lake - Manitowik Lake Fault which is one of many faults in the region

that are related to faulting in the Kapuskasing Structural Zone. Within the mineralized zone, the mineralized fractures and quartz veins have a trend of approximately 60° and dip 20 to 40°N (Skrechy 1981, p.7). The molybdenite mineralization increases northward towards the contact with the greenstone. While mineralized fractures and quartz veins are present in both rock types; trondhjemite and metavolcanic rocks, they show a decided preference for the trondhjemite (Skrechy 1981, p.6, 7). Only a few of the quartz veins and fractures are mineralized and the mineralization is highly erratic with alternating sections of very high and very low grade. Skrechy (1981, p.7) suggested that the lack of fine-grained molybdenite in the quartz veins and the observation that mineralized fractures cut across the quartz veins suggests that quartz veining and fracturing preceded mineralization. The author has noted that the molybdenite is concentrated along the quartz vein-wall rock contact and is not abundant internal to the vein. Fracturing displays a tendency to follow the vein walls.

A set of unmineralized tourmaline-bearing quartz veins cut the molybdenum-bearing quartz veins. These veins strike 60 to 75° and dip 50 to 75°N (Skrechy 1981, p.8).

The mineralization is strongly fracture-controlled and occurs as thin books of molybdenite disseminated in wall rock adjacent to the fractures, as fracture fillings up to 0.5 cm thick or as pockets of flakes in fractured quartz veins (Skrechy 1981, p.7). The highly erratic mineralization occurs in grains that locally may exceed 0.5 cm in size and on surface may be oxidized to bright yellow ferromolybdenite.

Molybdenite usually does not extend into the adjacent wall rock more than 1 or 2 cm, however, lenses of disseminated molybdenite up to 25 cm wide and 1 m long have been reported (Skrechy 1981, p.7). Minor pyrite, chalcopyrite, pyrrhotite and bornite occur with the molybdenite. A brecciated silicified vuggy shear zone in the northeast part of the Aldo Palma property contains silver-bearing galena (Skrechy 1981, p.5, 8). Skrechy also (1981, p.8) reported the presence of minor disseminated molybdenite in some pegmatite veins on the property.

Regardless of which of the three trondhjemite phases one examines the light grey weathering trondhjemite is the least altered and the greyish green trondhjemite is more altered and contains sericite (Skrechy 1981, p.54). Light pink trondhjemite is the most extensively altered (Skrechy 1981, p.54). Skrechy (1981, p.48, 54) reported this alteration to be generally one of enrichment in K_2O , SiO_2 , Rb and Zr and depletion in Fe_2O_3 , MgO , CaO , P_2O_5 , TiO_2 , MnO and Sr. He reported that Na_2O and SO_2 display variable trends (Skrechy 1981, p.48). Some of the mineralized fractures have a potassium feldspar alteration halo up to 2 to 4 cm wide while other fractures appear little altered (Skrechy 1981, p.8). Where quartz veining is abundant, sericitization of the plagioclase is intense and potassium feldspar alteration is superimposed on it (Skrechy 1981, p.8). Biotite, if present, is altered to chlorite. Dusty hematite in potassium feldspar imparts the red colour to the rocks. The presence of the hematite suggests alteration by a hydrothermal fluid with a high oxygen fugacity (Skrechy 1981, p.55). Little molybdenite mineralization occurs in the alteration halo and is restricted to fractures.

The pink to red alteration envelopes enclosing mineralized fractures are generally less than 5 cm wide and may contain microcline

porphyroblasts up to 2.5 cm in size with corroded plagioclase inclusions (Skrechy 1981, p.31). The large porphyroblasts may contain cross-cutting ribbons of quartz.

Skrechy (1981, p.55, 56) examined fluid inclusions in the mineralized fractures and interpreted the results as suggesting a fluid of moderate salinity. He suggested a possible relationship with pegmatitic activity in the area. The major findings of Skrechy (1981, p.58-61) are listed below:

1. The mineralization is a single fracture-controlled event possibly related to pegmatite activity.
2. The mineralizing fluid is magmatic in origin.
3. The alteration pattern of proximal pink potassium feldspar alteration enveloped in a greyish-green sericitic zone is comparable with alteration associated with porphyry copper-molybdenum deposits. The sericite zone is considered equivalent to the phyllic zone in porphyry copper-molybdenum deposits and the equivalent argillic or porphyritic zone was not recognized or is absent.
4. The molybdenite is coarse-grained at the Aldo Palma property but fine-grained in porphyry copper-molybdenum deposits.
5. The Aldo Palma molybdenite showing has an alteration pattern comparable with Cordilleran porphyry deposits.

Diabase dikes cut the mineralized zone leading to the development of a reddish colouration in the adjacent trondhjemite that fades with distance from the dike (Skrechy 1981, p.9). The reddish alteration is due to the presence of finely disseminated hematite. Granular and dendritic specularite occurs in quartz veins within this alteration zone and the molybdenite appears to have been leached from the quartz veins leaving clay filled vugs in the vein (Skrechy 1981, p.9).

Exactly when and by whom the molybdenite was discovered is unknown. It is reported that trenches and pits were excavated in the period 1936 to 1939 (MDIR, Toronto; Skrechy 1979, p.3).

FALCONBRIDGE MINES LIMITED

Falconbridge Mines Limited sampled the excavation in the fall of 1939 and cut 52 channel samples (MDIR, Toronto). It is reported that sampling of a trench in the northwest corner of the showing returned 0.313% MoS₂ over 22 feet and a second trench west of the first returned 0.373% MoS₂ over 20.6 feet; and a sample from a muck pile 800 feet farther west returned 0.44% MoS₂ (MDIR, Toronto). The company did not complete additional work.

DEEP LAKE GOLD MINES LIMITED

In 1943, 13 claims covering the showing were acquired by Deep Lake Gold Mines Limited. The company completed additional trenching and sampling. Four bulk samples taken by the company were assayed by the Mines Branch, Ottawa and returned 2.65, 4.92, 1.95 and 7.37% MoS₂ (MDIR, Toronto).

PAX INTERNATIONAL MINES LIMITED

In 1958, the property was acquired by International Ranwick Limited under option as part of a 31 claim block (MDIR, Toronto). The property was known at this time as the Peters-Quilty. The company completed sampling and geological mapping of the property. Plans for an adit were drawn up but never completed (Northern Miner, July 17 1958). International Ranwick Limited changed its name to International Molybdenum Mines Limited in 1959 and later in 1962 to Pax International Mines Limited (MDIR, Toronto).

BILLITON MAATSCHAPPIJ N.N.

The Billiton Company optioned the property from International Ranwick Limited in 1958 and completed three large BX diamond drill holes on the property. This drilling totalled 1896 feet. Aleva (1959) reported one 10 foot section from 170 to 180 feet in hole 2 averaged 0.25% Mo₂S. Values of 0.09 0.07 and two values of 0.05% Mo₂S were reported. He (Aleva 1959) reported that the average of 95 samples was less than 0.02% Mo₂S. The company dropped its option and the property reverted to International Ranwick Limited. The property was retained by the company through various name changes until it was dropped in 1967 (AFRO, Toronto). The property was dropped at approximately the time the company changed from Pax International Mines Limited to Geo-Pax Mines Limited.

AMAX MINERALS EXPLORATION LIMITED

The property was known as the Aldo-Palma property at the time it was optioned by Amax Minerals Exploration Limited in 1978. Six additional claims were also staked by the company.

The company completed a grid, geological survey, magnetic and stream sediment surveys over the property. The company cleared out and reblasted some of the old trenches and completed new stripping.

In 1980, the company completed one diamond drill hole totalling 54.7 m. From 1979 to 1980, the company completed 26 percussion drill holes, 8 of which were inclined (AFRO, Toronto). The percussion drilling totalled 735 feet. The results of this drilling is given in Table 29 and the hole location and simplified geology are given in Figure 84. The low molybdenum values discouraged the company and the option was terminated. No additional work has been completed on the property.

FIRESAND RIVER CARBONATITE

A large volume of exploration work has been completed on the Firesand River Carbonatite. Most of this work has been completed by Algoma Ore Properties Limited. This work has recently been discussed by Sage (1983a) and the reader should refer to that document for the exploration history. The Firesand River carbonatite is located in the northwestern corner of Lastheels Township but the larger part of the complex lies in the adjoining McMurray Township.

MID-NORTH ENGINEERING (37)

Mid-North Engineering completed three short diamond drill holes on the Morrison option in 1955. Two holes were on claim 43097. Drilling totalled 174.5 feet. The purpose of the drilling is uncertain but it is in the area along the Firesand River where the field party detected anomalous radioactivity. The source of this radioactivity was not located but it is assumed to be due to the presence of radioactive dikes associated with the Firesand River Carbonatite.

PANGO GOLD MINES LIMITED

As part of a large claim block, Pango Gold Mines Limited completed magnetometer surveys in the northwest corner and west side of Lastheels Township. Follow up work was not completed.

MCMURRAY TOWNSHIP

ALGOMA ORE PROPERTIES LIMITED (38)

Algoma Ore Properties Limited has been active in McMurray Township, principally in their investigations of the Firesand River Carbonatite. In 1980 and 1981, the company checked several geophysical targets for base metal mineralization.

ASSESSMENT DRILL HOLE A-7 (38-A)

Algoma Ore Properties Limited completed one diamond drill hole in 1953 on claim 22088 totalling 160 feet. No mineralization was indicated to be present. The drill log indicates the drill penetrated intermediate to felsic metavolcanic rocks (AFRO).

ASSESSMENT DRILL HOLE A-9 (38-B)

Algoma Ore Properties Limited completed one diamond drill hole totalling 1123 feet on claim 22578 in 1953. No mineralization was indicated in the drill log. The drill penetrated intermediate to felsic metavolcanic rocks and mafic intrusive rocks (AFRO).

MICHIPICOTEN BASE METAL PROJECT (38-C)

As part of the Michipicoten Base Metal Project, Algoma Ore Properties Limited drill tested airborne electromagnetic anomalies in the northern part of the township.

ANOMALY 12 (38-C-1)

The company completed two diamond drill holes totalling 498.5 feet on airborne electromagnetic anomaly 12, in 1981. The section from 71.5 to 78.2 feet in hole MB-4-81 consisted of cherty banded iron formation containing 8% pyrrhotite, 1% pyrite and 1% chalcopyrite (AFRO, Toronto). A second iron formation consisting of laminated chert and sulphide was intersected from 225.5 to 231.0 feet. The host rocks are intermediate to mafic metavolcanic rocks. The upper section varies from less than

0.001 to 0.005 ounces Au per ton, 0.04 to 0.05 ounces Ag per ton, 0.06 to 0.16% Cu and 0.07 to 1.16% Zn (AFRO, Toronto). The best Zn value of 1.6% was from 71.0 to 73.0 feet. The hole was drilled at an azimuth of 135° to a depth of 364 feet in north-facing stratigraphy. This demonstrates the zinc was concentrated at the stratigraphic top of the unit.

The lower iron formation gave values of 0.002 to 0.003 ounces Au per ton; 0.04 to 0.06 ounces Ag per ton, 0.05 to 0.16% Cu and 0.18 to 0.19% Zn (AFRO, Toronto). The better values are again at the stratigraphic top of the unit.

In the second hole (MB-13-81) on the anomaly, three conductive horizons were intersected. The conductors were from 39.5 to 42.9 feet, 89.5 to 94.2 feet and 109.0 to 112.5 feet. The first conductor contained up to 20% pyrrhotite, 3% pyrite and trace chalcopyrite. The second contained up to 3% pyrrhotite and 1% pyrite and the third up to 12% pyrrhotite (AFRO, Toronto). From the drill logs, the first intersection is a banded chlorite chert horizon, the second a banded chlorite-biotite-calcite-quartz schist and the third, a cherty sediment. Only the first horizon could be interpreted as iron formation from the drill log. On the basis of the drill logs anomaly 12 possibly consists of 3 conductive horizons, two of iron formation and two of metasedimentary rock or tuff. Assays on the upper unit were less than 0.005 ounces Au per ton, 1.3 to 2.4 ounces Ag per ton, 0.221 to 0.817% Cu and 0.0153 to 0.394% Zn; the middle section contains less than 0.005 ounces Au per ton, 1.9 to 2.1 ounces Ag per ton, 0.206 to 0.0702% Cu and 0.255 to 0.0321% Zn (AFRO, Toronto). The lower section returned less than 0.005 ounces Au per ton, 2.0 ounces Ag per ton, 0.084% Cu and 0.0317% Zn. The diamond drill hole was drilled at an azimuth of 315° in north facing stratigraphy. The assays indicate that for the upper and middle intersections, base metals are concentrated towards the stratigraphic top. The host rocks are intermediate to mafic metavolcanic rocks.

ANOMALY 30 (38C-2)

Anomaly 30 is located south of anomaly 12 within the same stratigraphic package. Anomaly 30 is in fact the Judith Iron Range.

Diamond drill hole MB-8-81 totalling 117.0 feet was completed almost entirely in brecciated iron formation cut by lamprophyre dikes. Sulphides consisting of pyrrhotite and pyrite occur throughout the hole and locally are estimated to comprise 70 volume % (AFRO, Toronto). Assays on the core gave less than 0.005 ounces Au per ton, 0.9 to 2.1 ounces Ag per ton, 0.0053 to 0.0283% Cu and 0.0056 to 0.0414% Zn (AFRO, Toronto). There is no consistent pattern to the reported values.

The second hole (MB-12-81) totalling 68.5 feet was completed in cherty iron formation cut by lamprophyre dikes. The sulphides pyrrhotite and pyrite locally comprise up to 20% of the core (AFRO, Toronto). Assays reported are less than 0.005 ounces Au per ton, 0.8 to 1.8 ounces Ag per ton, 0.0071 to 0.126% Cu and 0.0047 to 0.039% Zn (AFRO, Toronto). There is no consistent pattern of base metal distribution in the core.

ANDERSON PROPERTY (39)

Three claims immediately south of Wawa Lake are known as the Anderson

property (AFRO). This property was not visited during the present survey. From its location the host rocks are likely quartz-feldspar crystal tuffs. Several quartz veins occur on the property (AFRO). The main showing is known as Vein No.1 and is located approximately 800 feet west of the north end of a long linear lake. Sketch maps indicate the vein dips 28 to 55|N and has a strike of approximately 80| (AFRO, Toronto). On the basis of collected chip samples as indicated on the sketch maps, the vein varies from approximately 7 inches to 4 feet in width (AFRO, Toronto). The vein has a strike length exceeding 100 feet.

ERIE CANADIAN MINES LIMITED

The vein was apparently examined by Erie Canadian Mines Limited in 1938 and two samples collected (AFRO, Toronto). The results of the sampling are unknown.

HOLLINGER CONSOLIDATED GOLD MINES LIMITED

In 1944, Hollinger Consolidated Gold Mines Limited prepared a sketch map and sampled the property (AFRO, Toronto). One sample collected approximately 80 feet west of the lake where the vein is 7 inches wide returned 0.5 ounces Au per ton (AFRO, Toronto). All other assay values on the plan maps are nil to 0.01 ounces per ton. Correspondence on file indicates one sample ran 1.62 ounces Au per ton but the location of the sample was not given on the sketch map (AFRO, Toronto). No additional work by the company was reported.

SURLUGA GOLD MINES LIMITED

In 1966, Surluga Gold Mines Limited completed two diamond drill holes on the Anderson property. These holes were drilled on claim S S M 64705 and both were drilled from the same setup. This drilling totalled 506.5 feet and the results are unknown (AFRO, Toronto).

BARTON PROPERTY OCCURRENCE (40)

The Barton occurrence consists of two bands of iron formation 6 and 4 feet wide, respectively, separated by 7 feet of intermediate to mafic metavolcanic rocks (Collins and Quirke 1926, p.79). The bands strike at 165|, dip vertical and are traceable for 100 feet (Collins and Quirke 1926, p.79). The iron formation is described by Collins and Quirke (1926, p.79) as consisting of bands of granular silica separated by dark bands containing iron oxides and thin bands of pyrite. They reported that a 40 foot drift was driven into the wider iron formation band. This showing was not visited by the survey party.

HOLLINGER CONSOLIDATED GOLD MINES LIMITED

In 1938, the property was examined and sampled by Hollinger Consolidated Gold Mines Limited. One sample returned 0.02 ounces Au per ton over 3 feet and a second returned gold values (value unreadable on sketch map of sampling) over a width of 3 feet (AFRO, Toronto). The low

gold values are from porphyry (quartz-feldspar crystal tuff). All iron formation and almost all the porphyry samples were nil in gold content (AFRO, Toronto). No additional work has been completed on the showing.

BIG DOME PROSPECT (41)

This property was not examined by members of the field party. Rupert (1979, p.124) described the prospect as a wide glassy white quartz vein which has been exposed by pitting and trenching. The vein occurs on claims M 3250 and 3251. Gledhill (1927, p.47) described the strike of the vein as north and reported that 200 feet had been stripped by Cooper Gold Mines Limited but nothing of commercial interest was uncovered. The vein was described by him as being 30 feet wide narrowing to the north.

BLANCHE, C. (46)

(SEE DEEP LAKE GOLD MINES LIMITED)

BOHME, J.D.S. (42)

(SEE PANGO GOLD MINES LIMITED UNDER CITADEL GOLD MINES INCORPORATED)

CITADEL GOLD MINES INCORPORATED (42)

(FORMERLY SURLUGA GOLD MINES LIMITED,

FORMERLY PANGO GOLD MINES LIMITED,

FORMERLY PURSIDES GOLD MINES LIMITED)

Citadel Gold Mines Incorporated is an agglomeration of many former properties. These properties are the Cora, Hornblende, Mackey Point, Wawa Gold Fields, Cooper, Jubilee and Minto (MDIR, Toronto). The Cooper, Jubilee and Minto are former gold producers. The properties are covered by a group of 73 contiguous claims with the present Citadel shaft located on claim 59662 (MDIR, Toronto) (Plate 40). The shaft and workings are located next to or within the Jubilee Shear. The Jubilee Shear is exposed at the base of the cliff on the east side of Jubilee Lake. The Citadel Mine was unavailable for examination during the present project. The description of the mine geology is modified from Rupert (1979), who had the opportunity to examine the underground workings and from data accumulated by the company on the property. Since the various properties are characterized by different geologic settings, each former property will be discussed separately.

Rupert (1979) states:

"Descriptions of the geology of the Surluga (Citadel) Mine are largely abstracted from information kindly supplied to the author (R. Rupert) by C.J. Kuryliw, Mine manager in 1970 and geological consultant to the mine. Additional information has been obtained from newspaper clippings, mine plans and prospectuses on file in the office of the Ministry of Natural Resources in Sault Ste. Marie. The writer (R. Rupert) has briefly examined underground workings at the mine in 1970 with Mr. Kuryliw and was engaged as a geologist at the property for several months in 1964.

The Surluga (Citadel) Mine ore zones are all located in the Jubilee Shear zone, except for one small stope in the Hornblende Shear Zone which is a branch fault located 1,000 feet deeper than the Jubilee Shear at the shaft. As shown on Map P.828 (Rupert 1975) the Jubilee Shear zone extends south from Wawa Lake for a distance of over 2 miles. The average

strike of the shear zone is about 025|. In the mine, dips are easterly at 40| to 50| at the upper levels and at 30| to 35| at the fifth level. At each end it runs out into tuffaceous rocks where it cannot be traced as a clearly defined shear zone. The productive portion of the Jubilee Shear zone is restricted to the part where the wall rocks are predominantly diorites or granodiorites (Jubilee Stock). In the latter rock types the shear consists of a carbonatized and locally silicified sericitic to chloritic schist zone. The shear zone may bifurcate in places and some horses of unsheared rock are found in it. The walls of the shear zone are not necessarily clearly defined, but may be gradational. Late gabbroic dikes are intruded along the shear zone in places and cut across it at other locations. These dikes may be nickeliferous and in the vicinity of the shear zone they may be schistose.

In the vicinity of the mine, large xenoliths of metavolcanic rock are present in the dioritic intrusive pluton (Jubilee Stock). These random inclusions are of a size comparable to the size of the ore shoots and their presence in or near the shear zone may be a controlling factor in localizing ore shoots.

Based on geological mapping and reports by C.J. Kuryliw, the following descriptions of the ore zone was published in the prospectus of Pursides Gold Mines Limited, dated July 1973.

At the Pursides property, a shear structure known as the Jubilee Shear is host to gold-bearing zones. The shear structure consists of a complex of sericitic and chloritic schists that pinch and swell along trend. Sheared gabbroic sills commonly occur at the hanging wall and/or footwall of the shear structure. At the north end of the mine workings the shear strikes N35|E and at the south end of the workings it strikes N10| E.

The schists of the shear structure consist of mixed sericitic and chloritic schists. The gold-bearing portions are silicified and mineralized in a zoning related to depth with gold content generally increasing in grade and volume with depth.

The schists within the shear structure pinch and swell along strike from a width of 20 feet up to 200 feet. These swells have been termed zones which follow a generalized pattern. Each zone follows a general southeasterly plunge along the shear structure which gives a 15| to 20| south-easterly rake to the zones. Down dip, the shear structure gradually increases in width and then abruptly pinches, this pinching of the schists down dip follows a fairly regular traceable "bottom pinch" that plunges 11| southward.

The richer gold-bearing "shoots" occur within zones. The grade appears to be related to associated mineral zoning. In general, the richer gold-bearing "shoots" occur in association with pyrite and arsenopyrite where the intervening schist between parallel "shoots" is also commonly weakly silicified and mineralized to give low grades of 0.01 to 0.05 oz. Au/ton. The mineral zoning is in turn spatially related to its distance measured along the shear perpendicular to the trace of the "bottom pinch" plunge.

Thus, three types of mineral zones carry gold at the Pursides Mine: the upper gold-bearing zone is associated with quartz-tourmaline mineralization and averages 0.05 to 0.15 oz. Au/ton, this is followed by a deeper zone of quartz-pyrite mineralization with values ranging from 0.20 to 0.40 oz Au/ton, which, in turn is followed by a deeper quartz-

arsenic gold-bearing zone of mineralization that averages 0.20 to 0.50 oz. Au/ton.

"Free gold mineralization occurs finely dispersed like a fine "yellow fog" even in high grade intersections so that exceptionally high grade intersections are rare."

The galena and sphalerite mineralization below the "bottom pinch" of the ore shoots is restricted to narrow veins or veinlets of quartz and some carbonate. None of these have been found to have a large enough size to justify mining.

Between the "zones" in the shear as defined in the preceding quotation, veins or silicified sections of the shear zone, composed of white glassy "bull" quartz and fine needles or masses of tourmaline may be present. Although visible gold is sometimes present in these quartz tourmaline zones which are similar in size to the ore shoots, experience has shown that mining them is generally unprofitable.

The ore shoots in the shear zone may vary from veins of quartz with less than 20% of included wall rocks to finely interbanded silicified schist and quartz veinlets having a ribboned appearance. The presence of fine pyrite or arsenopyrite may impart a grey colour to banded quartz.

Definition of ore reserves at the mine is and has always been the most difficult aspect of mine operation and failure to achieve predicted grade during production has created serious financial problems for the operators. Because of the interbanded nature of the ore shoots, there is no exact physically recognizable boundary between ore and waste. Of necessity, assay boundaries based on sampling of mine openings or diamond drill intersections have been used to establish ore limits. This procedure inherently is biased in favour of selected high assays and as a result, the selected assay values are not representative of the rock sampled. When subsequently used to estimate the grade of the body of rock which was selected on basis of these sample results, the average of the assay values is invariably too high.

This problem is not caused merely by the presence of erratic high assays in the sample results. In fact, exceptionally high values are rare and it has not been practical to use conventional cutting procedures as an aid to estimating ore grade.

The problem is related mainly to the fact that the sample results are used to define an ore zone with a bias in favour of high values and that once this is done, the same samples can no longer be considered representative.

Individual ore shoots as indicated on underground plans by stope outlines and ore zones shown on geological plans are distinctly elongated. The size of individual shoots as defined in the preceding quote (by R. Rupert 1979) from the 1973 Pursides prospectus varies widely but ratios of the lengths measured along the plunge to the lengths measured perpendicular to the plunge in the shear zone are fairly constant. Ore shoots mined in previous operations have ranged up to 280 feet in length, 90 feet along the dip and about 15 feet in maximum perpendicular thickness. This shape of ore shoots makes projection of ore intersections between levels difficult and numerous raises are required to locate and evaluate ore zones. Exploratory development has been the major expense for previous operators.

Insofar as the individual ore shoots and groupings of ore shoots plunge in a southerly or southeasterly direction, further ore may be present between the Surluga and Jubilee Shafts and the extension of the Jubilee Shear Zone beneath the Minto Mine. Current exploration operations are directed towards that area."

The author has compiled existing surface diamond drilling in Table 30. Figure 85 presents a plan view of underground developments and ore zones, projected to surface. Figures 86A, B and C indicate position of surface drill holes and some of the more pertinent assays.

The formation of the present Citadel Gold Mines Incorporated property began in the 1950's when T. Surluga began staking former properties in the area (Rupert 1979, p.81). After obtaining several claims east of the Jubilee Shear Zone, he brought them to the attention of W.D. Sutherland who enlarged the property by optioning, buying, or staking (Rupert 1979, p.81). Property acquisition continued into the 1970's.

SUTHERLAND AND COMPANY

In 1960, Sutherland and company acquired the 8 claim Cora Group and completed a 25 hole surface drilling program in the Jubilee Shear zone between 1960 and 1961 (MDIR, Toronto). The company also acquired an additional 28 claims during this period of time.

SURLUGA GOLD MINES LIMITED

In 1962, Surluga Gold Mines Limited was formed by Sutherland and company and an additional 37 claims acquired (MDIR, Toronto). Surface drilling of the Cora group between 1962 and 1963 partially outlined 225,226 tons grading 0.232 ounces Au per ton in 5 ore shoots.

The Cora property was then optioned in 1964 by Consolidated Mining and Smelting Limited and a surface drill program of 20 diamond drill holes completed (MDIR, Toronto; Kuryliw 1972, p.12). The company dropped the option on June 18 1964.

Between 1964 and 1968, Surluga Gold Mines sank a 950 foot 3 compartment shaft with 7 levels at approximately 150 foot intervals on the former Cora property (MDIR, Toronto; Kuryliw 1972, p.12).

Proven reserves of 148,040 tons grading 0.278 ounces per ton, possible reserves of 90,360 tons grading 0.305 ounces per ton and probable reserves of 2,632,600 tons grading 0.285 ounces per ton were indicated in 1967 (Surluga Gold Mines Limited 1967 Annual Report).

In 1972, three independent engineers were employed to calculate tonnage and grade figures (Kuryliw 1972). The first engineer interpreted the data to indicate the absence of proven reserves and the second calculated 277,744 tons at 0.245 ounces per ton or 305,518 tons at 0.222 ounces per ton with 10% dilution (Kuryliw 1972, p.13). The third engineer calculated 286,114 tons at 0.2795 ounces per ton or 330,000 tons grading 0.236 ounces per ton with 30% dilution (Kuryliw 1972, p.13).

Grade and tonnage figures for the Surluga property vary considerably between investigators.

In 1967, the company started construction of a 750 ton per-day mill which was in operation by 1968 (MDIR, Toronto). The recovery was 86.92%

or equivalent to 0.167 ounces per ton (MDIR, Toronto). The mill was shut down in 1969 but underground development continued.

In 1969, Prado Explorations Limited Joined with Surluga Gold Mines Limited to continue exploration (MDIR, Toronto).

Prado Exploration Limited assigned its interest to Pango Gold Mines Limited and Ballinderry Explorations Limited agreed to advance \$100,000 to Surluga Gold Mines Limited for 1% of the net profits resulting from the joint venture (MDIR, Toronto). Surluga Gold Mines Limited changed its name to Pursides Gold Mines Limited in 1973 (Canadian Mines Handbook 1973-1974, p.325) and was forced into receivership in 1976 (Canadian Mines Handbook 1977-1978, p.259).

The 750 ton per-day mill is owned 100% by Pursides Gold Mines Limited which in turn is 65% owned by Prairie Pacific Energy Corporation (MDIR, Toronto). Pursides Gold Mines Limited remains in receivership and Prairie Pacific Energy Corporation is attempting to reorganize the company. The Northern Miner (January 31, 1980, p.27) reported reserves on the developed property to be 755,000 tons averaging 0.148 ounces Au per ton (cut and diluted) with an additional potential of 870,000 tons averaging 0.13 ounces Au per ton and that 27,000 tons of broken ore averaging 0.12 ounces Au per ton lie in stockpile at surface.

In 1980, Pursides Gold Mines Limited changed its name to Citadel Gold Mines Incorporated (Canadian Mines Handbook 1981-1982, p.285). The former Surluga property is presently controlled by Citadel Gold Mines Incorporated (42%) and Pango Gold Mines Limited (58%) (Canadian Mines Handbook 1984-1985, p. 92). Citadel Gold Mines Incorporated is 70% controlled by Prairie Pacific Energy Corporation.

PANGO GOLD MINES LIMITED (42) (42A)

Pango Gold Mines Limited became part owner in the operations of Surluga Gold Mines Limited in 1969 and in 1970 and 1971 embarked on an ambitious exploration program centered south and east of the mine outside of the Cora group on which all major development had taken place.

In 1981, Pango Gold Mines Limited drill three holes on claims in the Ward Lake area. This drilling totalled 700 feet and encountered gabbro, lamprophyre dikes, granitic rocks of the Jubilee Stock and various units of Jubilee tuff. Assay data was not reported. Drill hole 1 was completed on claim S S M 430236, hole 2 on claim S S M 430235 and hole 3 on claim S S M 430232 (AFRO).

The company completed geological surveys and ground magnetometer surveys over its various claim blocks throughout McMurray Township and extending into Esquega and Lastheels townships. These data were used extensively by Rupert (1975) to compile the first geological map of the township.

The company completed one diamond drill hole number 1971-1 for a total of 444 feet on the north side of Reed Lake. From 254 to 270 feet, nickel assays varied from 0.12 to 0.21% and from 342 to 350 feet nickel assays were 0.15 to 0.17% (AFRO, Toronto). Copper or platinum group element values were not reported. The sulphides are fine- to very fine-grained and are disseminated throughout sections of the core that were logged as peridotite (AFRO, Toronto). Gabbro and amphibolite also are described in the core log. Sulphides are indicated on the drill log to approach 3% of

the core and magnetite may be present in amounts of 5%. Polished sections examined by Boorman (1971) disclosed minor amounts of pentlandite and chalcopyrite and traces of cobaltite in addition to pyrite, pyrrhotite and the spinels.

Reports on file in AFRO under J.D.J. Bohme may result from the work completed by Pango Gold Mines Limited.

COOPER MINE AND GANLEY VEIN (42B)

The Cooper Mine and Ganley Vein have been described by Moore (1931, p.39) and Gledhill (1927, p.42). The workings of the Cooper Mine are exposed at surface along the trail to Stanley Lake. The Cooper Mine vein and Ganley Veins are considered to be the same vein by Gledhill (1927, p.42) and Weeks (1928, p.10c), but Rupert (1979) and Moore (1931) indicated that they are two separate veins). The Cooper Mine Vein varies between 1.5 and 4 feet in width and dips 45° NE (Moore 1931, p.35). The vein is reported to strike 30° (Gledhill 1927, p.42). Weeks (1928, p.10c) reported the vein to strike 75° west of north, have a fairly even width of 2 feet and dips 43° NE. Mapping by Gledhill (1927) indicated that the strike of the Cooper and Ganley veins given by Weeks (1928) is the correct one. Gledhill (1927, p.42) reported that gold mineralizations is erratic and occurs chiefly in vugs. He also reported that gold values are more consistent in the vein where sulphides are more abundant.

The Ganley Vein runs parallel to and is approximately 250 feet south of the Cooper Mine Vein (Rupert 1979, p.78; Moore, 1931, p.39). Rupert (1979, p.78) reported that the vein is 4 feet wide and cuts dioritic rocks of the Jubilee Stock which contain abundant xenoliths of metavolcanic rocks. Moore (1931, p.39) states the vein contains considerable pyrite, chalcopyrite, pyrrhotite and tourmaline. Rupert (1979, p.78), however, indicated that the sulphide content in the quartz is minor. Moore (1931, p.39) indicated that the vein becomes more shallow dipping towards the north approaching 25° E. Rupert (1979, p.79) indicated that mine plans fail to establish this shallow dip.

COOPER GOLD MINES LIMITED

Gold was discovered in the Cooper Mine and Ganley Vein some time around 1900 by persons unknown (MDIR, Toronto). From 1925 to 1926, the property was owned by Pioneer Mining Corporation and from 1926 through 1930, it was owned by Cooper Gold Mines Limited a subsidiary of Pioneer Mining Corporation (MDIR, Toronto, Weeks 1928, p.10c). Gledhill (1927, p.42) reported that the Cooper Mine Vein was diamond drilled by Pioneer Mining Corporation and Rupert (1979, p.78) reported the diamond drilling took place in 1926. No record of this work could be found by the author, but it is reported to total 1,346 feet of drilling (AFRO, Toronto).

MINTO GOLD MINES LIMITED

In 1930, Minto Gold Mines Limited was formed to take over the Minto, Jubilee and Cooper properties (Sinclair 1939, p.167). In August 1938, the mine was reopened on the Cooper Mines Vein and 4,889 tons of ore

recovered (Rupert 1979, p.78; Sinclair 1939, p.168). Sinclair (1939, p.167) indicated that the property was developed by an inclined shaft at 45° to a depth of 65 feet. A level was made at 50 feet and 210 feet of drifting and 100 feet of raising were completed. Rupert (1979, p.79) reported that stoping was continuous for 50 feet on the incline for a distance of 230 feet on the first level. Sinclair (1939, p.168) reported stripping and trenching were also completed at this time. The gold production from this vein is discussed by Rupert (1979, p.78) as follows:

"Separate gold production figures for the Cooper Mine are not available since ore was trucked to the Minto mill where Jubilee Mine ore was also treated in 1938. Total production at the Minto mill for 1938 was 2,114 ounces of gold from 7,931 tons of ore. According to O.D.M. annual reports 4,889 tons of this ore came from the Cooper Mine. If the remainder came from the Jubilee Mine and equalled the average grade of \$4.70 per ton established for that mine and if salvage and clean-up of the mill is ignored, then the residual Cooper production was 1,772 ounces of gold from 4,889 tons of ore. This latter estimate may be slightly high due to the effect of mill clean-up."

The 65 foot Cooper shaft is reported to be on claim S S M 3090 and a 50 foot vertical shaft on the Ganley vein (Ganley shaft) is reported to be present on claim S S M 4020 (AFRO, Toronto). There is no record as to when these shafts were originally sunk. The property was abandoned by Minto Gold Mines Limited in 1952 and eventually became part of the Citadel Gold Mines Incorporated holdings when obtained by Surluga Gold Mines Limited in 1962 (AFRO, Toronto). The vein likely extends below the old workings but there is no indication of possible depth or grade.

Rupert (1964, p.78) reported that the Cooper vein was diamond drilled by Marboy Mines Limited. There is no record of this company working on this vein.

In 1969 Surluga Gold Mines Limited completed 5 vertical diamond drill holes on the Cooper Mine Vein. This drilling totalled 1464 feet and the location of 3 of the 5 holes is uncertain. Values range from trace to 0.40 ounces Au per ton. The higher gold values were generally over relatively narrow widths.

There has been no recent work on the property.

CORA GOLD MINES LIMITED

The former property of Cora Gold Mines Limited is now the main property on which the present Citadel Gold Mines Incorporated has completed most of its development and exploration work. The geology of this property is discussed under Citadel Gold Mines Incorporated.

It is unknown as to who originally staked the property but Cora Gold Mines Limited completed pitting and trenching in 1927 (MDIR, Toronto). The company completed 3 diamond drill holes at this time with reported negative results. The records for this work could not be located.

Gledhill (1927, p.45) indicated that this work may have been completed by the Power and Mines Syndicate under an option arrangement. The original property may have consisted of only two claims. No additional work was completed until the property became part of the holdings of

Sutherland and company in 1962. The property is now within claim S S M 59662. Weeks (1928, p.9c, 10c) referred to this property as the Cora and the Stobie property claims north of the Cora were once owned by James Stobie and these claims have been referred to as the Stobie property.

HORNBLENDE PROPERTY (42C)

The precise location of the Hornblende Vein is unknown. Gledhill (1927, p.42) described the Hornblende Vein as striking east and dipping south. This strike is a variance with the northeast strike of the Hornblende Shear Zone where this vein is thought to exist. Gledhill (1927, p.42) described the vein as having a sheared diorite wall rock and that it shows replacement by tourmaline and biotite.

Rupert (1979, p.125) considered the Hornblende Shear Zone to be a splay structure branching off of and situated below and west of the Jubilee Shear Zone. The Hornblende Shear Zone was mined at the site (42C) indicated on the map and as well as on the 7th level of Citadel Gold Mines Incorporated (Rupert 1979, p.125).

The Hornblende Shear is described by Rupert (1979, p.125) as wide, poorly defined and exposed in a cliff face. Wall rocks were described by him as diorite of the Jubilee Stock and quartz crystal tuff. The shear strikes at 120° and dips 80°S (Rupert 1979, p.126).

HORNBLENDE MINING COMPANY LIMITED

The original claim was staked in 1900 and developed by the Hornblende Mining Company Limited (Rupert 1979, p.125). Two inclined shafts of 22 feet and 32 feet were sunk on a glassy quartz vein up to 4 feet wide in the Hornblende Shear Zone (Boyd 1900, p.114). A test mill was constructed at the site (Gledhill 1927, p.43). The results of mill testing are unknown. Rupert (1979, p.125) reported finding visible gold at the site.

JUBILEE MINE (42D)

The former Jubilee Mine is located within the Jubilee Shear Zone adjacent to the workings of Citadel Gold Mines Incorporated. The Jubilee Shear Zone strikes 20° and dips 35°E within the mine (Frohberg 1935, p.77, Weeks 1928, p.8c). The ore body is described as a coarse, glassy quartz lens varying from 10 to 40 feet in width and over 600 feet in length (Frohberg 1935, p.77). Frohberg (1935) described the quartz lens as increasing in width to an inclined depth of 640 feet, however, gold values decrease with depth. Gledhill (1935, p.77) reported that the quartz contains large aggregates of tourmaline and ankerite and minor quantities of pyrite, pyrrhotite and chalcopyrite. He reported rare native gold.

The shear zone contains abundant inclusions of country rock which along with the quartz is traversed by a intricate network of red quartz-carbonate veins which locally impart a red colour to the rock (Frohberg 1935, p.77).

The quartz body and shear zone is cut by late strike-slip faults. Smooth gouge-filled fractures are present below and above the gold zone

(Frohberg 1935, p.77). A hard, dense grey to pink aplite cuts the shear zone on the 3rd and 4th levels and is in turn cut by red feldspar-carbonate veins, lamprophyre dikes and faults (Frohberg 1935, p.7). Frohberg (1935, p.77) also reported that fresh unsheared diorite intruded the shear zone.

Rupert (1979, p.92) on the basis of examining old mine plans casts doubts on there being only one ore zone. He concluded the following:

"Frohberg (1935, p.54) has published a good photograph of the ore. The writer finds it difficult to reconcile Frohberg's description of "one continuous quartz body" with the pattern of drifts and crosscuts on the final underground plan dated July 31, 1939. It would appear that other zones were subsequently developed before the mine closed.

The width of the shear zone may be over 100 feet in true width. In the part of the mine with the most intense development work, the crosscuts extended 240 feet horizontally across the shear zone. The quartz zone (s) was near the footwall of the shear zone on the upper north levels and was located progressively nearer the hanging wall of the shear zone at the lower south levels. The long axis of the zone mined plunged at about 17° to the south-southeast, as indicated on the mine plans."

Rupert (1979, p.92) described the host rocks to the Jubilee Shear Zone as intermediate to felsic intrusions with metavolcanic inclusions varying from mafic to felsic in composition which have undergone varying stages of assimilation. The author, however, observed that due to the sharp angular nature of the metavolcanic xenoliths and sharp metavolcanic-intrusion contacts there was no assimilation of xenoliths.

GREAT NORTHERN MINING COMPANY LIMITED

In approximately 1897-1898, the Great Northern Mining Company Limited had sunk a 7 by 9 by 103 foot shaft on the property (Boyd, 1899, p.102; Collins and Quirke 1926, p.120). Gledhill (1927, p.37) reported that a L. Peters found gold in the sericite schist on the west shore of Jubilee Lake and Weeks (1928, p.8c) attributed the discovery of gold at the Jubilee mine to Mr. Peters in 1926.

Great Northern Mining Company Limited had a 75% interest in the property and a A. Lauzon and J.H. Lawlor had 12.5% each. Gold values encountered in the shaft sinking were negligible (Rupert 1979, p.89). Weeks (1928, p.9c) stated that the Jubilee Shear Zone on the west side of the lake is separate from the Jubilee vein on the east side even though they are closely spaced and parallel work on the east side of Jubilee Lake took place early in the history of the area but the discovery of gold by Mr. Peters on the west side of Jubilee Lake in 1926 stimulated additional development.

COOPER GOLD MINES LIMITED

The original claim lapsed and was restaked in 1923 by the Michael Syndicate. Gold values were encountered in the footwall of the Jubilee Shear Zone (Rupert 1979, p.90). The property was optioned to Pioneer Mining Corporation Limited in 1926 and a 30 hole diamond drill program

completed from the east side of Jubilee Lake (Rupert 1979, p.90). Drilling indicated gold values to an inclined depth of 525 feet and underground development was begun by Cooper Gold Mines Limited, a subsidiary of Pioneer Mining Corporation Limited, in 1927. Records for the drilling and other work could not be located by the author. From February 1929 to March 1929, a 20 ton per day mill treated 2,462 tons of ore recovering \$8,743 worth of bullion (421.8 ounces at \$20.73 per ounce, Robinson 1932, p.81). The mine was abandoned and allowed to flood in 1930. Development to this date consisted of an inclined shaft at 331 to a depth of 550 feet (292 feet vertical) with levels at 180, 290, 411 and 535 feet (MDIR, Toronto). The lower level is reached by a winze sunk at a angle of 50° from the level above (Rupert 1979, p.91). Moore (1931, p.38) reported that approximately 8,000 feet of lateral work had been completed from the shaft.

MINTO GOLD MINES LIMITED

Early in 1930, a lease-purchase was granted to J. Knox Jr. (MDIR, Toronto, Robinson 1935, p.110, 111). Minto Gold Mines Limited was incorporated in July 1930 and took over the Jubilee property from Mr. Knox in 1931 (MDIR, Toronto). Minto Gold Mines Limited took over complete ownership of the property in approximately 1934.

Operations at the Minto Gold Mine came to a close in 1934 and ore was trucked from the Jubilee Mine to the Minto mill until 1939 (MDIR, Toronto). Rupert (1979, p.93) described the gold production from the Jubilee Mine as follows:

"Production from the Jubilee Mine from 1929 to 1939 totalled 118,992 tons. In 1938, 2,962 tons of Jubilee ore and 4,889 tons of Cooper Vein ore were treated together and jointly reported to produce 2,114 ounces of gold. If it is assumed that the 2,962 tons of Jubilee ore mined in 1938 yielded gold at the average rate for other years (0.115 ounces per ton), then the total gold production from the mine, including salvage in 1942 was 14,156 ounces of gold. It is worth noting that Minto Gold Mines Limited undertook production as a salvage operation in 1934, when most of the development costs were already expended by Minto's predecessor. The net profitability of the operations from 1927 to 1939 is very doubtful."

The Jubilee Mine has been abandoned since production ceased in 1939. Rupert (1979, p.90) reported that the mine caved into Jubilee Lake on May 31, 1939. The Jubilee Mine workings are not connected to the workings of Citadel Gold Mines Incorporated. During mapping of Jubilee Lake, two inclined shafts were located by the field party on the east side of the lake. These workings are very old and no information could be located concerning them. Reports by MacLeod (1927) and Dorfman (1927) give some early exploration history on both the Jubilee and Minto Properties.

MACKEY POINT (42E)

Mackey Point on the south shore of Wawa Lake is the site of the first gold discovered in the Wawa area. The gold occurs in quartz veins cutting coarse-grained metagabbro. The quartz veins strike approximately

15 to 30° and dip moderately north and south (Frohberg 1935, p.75). Rupert (1979, p.121) described the quartz veins on Mackey Point as varying from 2 inches to 2 feet in width. They contain tourmaline, pyrite, pyrrhotite, chalcopyrite and sphalerite but no visible gold (Rupert 1979, p.121). The only geological examination made on the showings was that of E.M. Burwash and a very brief examination by Weeks (1928, p.100). Frohberg (1935, p.76) quotes the observations of Burwash however the notes taken by Burwash have been lost and could not be located by the author. Pertinent observations by Burwash cited by Frohberg (1935, p.75, 76) are as follows:

"These veins lie one above the other and dip into the cliff at 25° to 30° E, their strike being approximately N15° E. A shaft 41 feet deep was sunk on the lower vein, not far north of the road leading from Wawa to Gold Park. The upper vein, which was opened up by a shaft about 375 feet farther north, lies about 40 feet above the lower. This shaft follows the vein down about 90 feet, at which point the vein appeared to be cut off by a fault.

The veins in both shafts are between 3 and 6 feet wide and are composed of a glassy type of quartz, with which are associated carbonate, black tourmaline and feldspar. The quartz contains numerous inclusions of country rock and in many places is cut by red feldspar-carbonate veinlets. The mineralization of the veins consists of pyrite, pyrrhotite and chalcopyrite. Visible gold is said to have occurred in the shaft on the upper vein not far from the surface.

Another eastward-dipping vein called the "Root lens" is located some distance to the northwest. It strikes about N30° E. and has been exposed for over 100 feet. Most of the quartz is granulated in appearance and is cut by a later generation of quartz. Pyrite and tourmaline are conspicuous constituents."

Rupert (1979, p.123) reported the Jubilee Shear to be 300 feet wide on the point and that it contains blocks of unshered rock. The wall rocks consist of diorite and lapilli tuff. Sections within the shear are intensely carbonatized.

The original discovery of gold was by Mrs. William Teddy in 1897 whose husband sold the location to J.M. Dickinson who in turn transferred it to J.J. Mackey and J.L. Caverhill (Rupert 1979, p.121).

By 1900, pitting and trenching had been completed and a 8 by 10 by 40 foot shaft completed (Boyd 1900, p.114). This early work was completed by J.J. Mackey and J.L. Caverhill.

A 266 pound sample of gold ore was shipped to the Department of Mines, Canada Mines Branch, Ottawa in early 1933 for mill testing and a good recovery made (AFRO, Toronto).

CONSOLIDATED MINING AND SMELTING COMPANY OF CANADA LIMITED

In 1933, the claims were optioned to Consolidated Mining and Smelting Company of Canada Limited from Mackey Point Syndicate who then completed a considerable amount of work on the property (Frohberg 1935, p.75). The company is reported to have sunk one inclined shaft at 25° to a depth of 252 feet on claim Y104 with levels at 130 and 230 feet (MDIR, Toronto).

Drifting and crosscutting totalled 244 feet. The company completed 15 diamond drill holes totalling 4,835 feet. The company sunk a second shaft on the property to a depth of 41 feet (MDIR, Toronto). After completing an extensive sampling program, Consolidated Mining and Smelting Company of Canada Limited dropped their option in 1936 and Mackey Point Gold Mines Limited was incorporated to take over the property (MDIR, Toronto).

MACKAY POINT GOLD MINES LIMITED

Mackey Point Gold Mines Limited completed trenching, pitting and 4,285 feet of diamond drilling (MDIR, Toronto). Records for work completed by Mackey Point Gold Mines Limited could not be located.

One lens known as the "Root" is reported to contain 130,000 tons of unspecified grade (MDIR, Toronto). No additional work has been reported on the property. In approximately 1962, the former Mackey Point Gold Mine Limited property became part of holdings of Sutherland and company forerunner to Citadel Gold Mines Incorporated.

MINTO GOLD MINE (42F)

The Minto Vein strikes 340° and dips 48° NE (Gledhill 1927, p.36). The vein has been segmented into three sections by cross faults. A set of northeast-trending veins are present which are subparallel to the faults (Gledhill 1927, p.36). These northeast-trending veins contain carbonate, tourmaline, minor, sulphide and sporadic but minor gold.

The hanging wall to the Minto Vein is chlorite schist. Moore (1931, p.38) indicated that the veins cut sheared diorite and quartz porphyry. The Minto Vein structure is composite with two distinct attitudes and contains numerous inclusions of felsic metavolcanic rocks (Rupert 1979, p.96). The ore-bearing part of the vein may be up to 10 feet wide but averages 58 inches (Rupert 1979, p.96). This part of the vein strikes 155° and dips northeast at approximately 45°. The footwall is unsheared but Rupert (1979, p.97) reported the hanging-wall is sheared up to widths of 5 feet in proximity to the vein. In contrast to Gledhill who stated the ore vein has been segmented into three segments by faults, Rupert (1979, p.97) reported the presence of 4 cross-faults with right hand offset varying between 10 and 200 feet. These faults are reported by him to strike at 55° and dip southeast at 60 to 82°.

Gledhill (1927, p.36) indicated these faults are post-ore even though mineralized. Rupert (1979, p.97) suggested that since the veins occupying these faults are also mineralized that they are a complementary part of the ore-bearing structure and contemporary with it. He (Rupert 1979, p.97) considered the northeast-trending faults to be less favourable to mineralizing fluids and that the main northwest-trending ore zone is a dilatant fissure opened at an S-shaped irregularity in the northeast striking faults.

Using available underground plans and the reports of Gledhill (1927) and MacLeod (1927), Rupert (1979, p.97) has postulated the following attitude for the ore shoot:

"The attitude of the ore shoot in the mine is not clear from the

descriptions by Gledhill and MacLeod. However, the location of raises and the lengths of ore sections implied by MacLeod's summaries of tonnage and width at each level indicate a southeast rake for the ore zone, roughly parallel to the intersection direction of the two attitudes of the vein structures. This direction of rake matches Froberg's statement that the rake is generally to the right of a person facing down the dip of the vein."

The ore from the Minto Mine is described by Gledhill (1927, p.37, 38) as follows:

"In the Minto vein native gold can rarely be seen with the naked eye; it is generally fine and mixed with fairly coarse and massive pyrrhotite, pyrite and chalcopyrite. The sulphides are usually massive and seldom have crystal outlines. Patches of massive sulphides several feet across were seen.

The vein in certain places shows massive sulphides with no thin bands of schist included in the quartz; in other places the schist, altered to biotite, forms dark seams through the quartz. Quartz of this type is more granular than the variety with no schist inclusions. In places the seams of schist are replaced by sulphides and this in turn has been favourable for gold deposition.

The sulphides are usually intimately intergrown, but separate areas of each are also common. In some cases the sulphides are finely crushed and these crushed bands in places outline the massive sulphides.

The coarsely crystalline ankerite in the Minto vein contains pyrite, chalcopyrite and pyrrhotite and gives fair gold assays.

It might be said that the higher values in gold are dependent on: (1) extensive crushing in the vein; (2) the amount of sulphides (the more sulphide the higher the gold content); (3) the crushing of the sulphides (fractured and crushed vein sulphides carry more gold than the massive ones); (4) the presence of chalcopyrite, especially fractured chalcopyrite. Chalcopyrite is favourable because it was the sulphide precipitated just prior to the gold.

It is probable that the ore emanated from the more acidic facies of the batholith since the ore solutions contained boron, for the formation of tourmaline and potash to form biotite and sericite."

Rupert (1979, p.99) reported the ore averaged 0.33 ounces Au per ton with the best ore occurring between the first and second levels. Grades were lower on the lower levels. Gold production from the Minto Mine was compiled by Rupert (1979) and is given in Table 31.

The original Minto discovery was by S. Berailldt in 1897 who sold it to D. Tisdale (MDIR, Toronto; Gledhill 1927, p.35). Stripping, pitting and an inclined shaft were sunk approximately 130 feet (MacLeod 1927, p.1). Loughrin (1926, p.1) indicated the inclined shaft dips at 70° however the vein dips 45° northeast and it would seem likely that the shaft was sunk in or parallel to the vein. Work was suspended in 1900 (Boyd 1901, p.39).

The property reverted to the crown in approximately 1922 and was restaked by the Wawa or Michael Syndicate in approximately 1923 (MacLeod 1927, p.1, MDIR, Toronto).

COOPER GOLD MINES LIMITED

The Minto property was sold in 1926 to Cooper Gold Mines Limited a subsidiary of the Pioneer Mining Corporation (AFRO, Toronto). The inclined number one shaft was dewatered and a station cut at 100 feet or 85 feet vertical depth and 1,818 feet of drifting and crosscutting completed in 1926 and 1927. Seven surface diamond drill holes totalling 2,533 feet were also completed at this time (MacLeod 1927, p.7; AFRO, Toronto). Records for this work could not be located.

In approximately 1926, a three compartment vertical shaft 6 by 14 feet was put down to a depth of 345 feet (MacLeod 1927, p.5; Moore 1931, p.37). Levels were established at 125, 225 and 325 feet and 4,000 feet of drifting completed (Moore 1931, p.37).

MINTO GOLD MINES LIMITED

In 1930, a lease-purchase arrangement was made with J. Knox, Minto Gold Mines Limited was incorporated in 1930 and the property transferred to the company in 1931 (Rupert 1979, p.95; Moore 1931, p.36). The Minto, Jubilee and Cooper properties were purchased by Minto Gold Mines Limited from Cooper Gold Mines Limited. A 75 ton per day cyanide mill was constructed in 1930 to 1931 and the property was in production from 1931 until June 1934 (Rupert 1979, p.95). This mining was a salvage operation and the mill continued to operate until 1939 with ore from the Jubilee and Cooper properties. Tailings were disposed of in Minto Lake. There is no record of ore reserves remaining in the mine.

The Minto property became part of the Surluga Gold Mines Limited holdings in 1962 and subsequent work is discussed under Citadel Gold Mines Limited. Surluga Gold Mines Limited or its following corporate structures have not completed work directly on the Minto Vein.

Rupert (1979, p.95) suggested that Lake Osu Mines Limited may have completed work on the property but there is no record of this work.

WAWA GOLD FIELDS LIMITED (42G)

The former Wawa Gold Fields Limited property adjoins the former Mackey Point Gold Mines Limited property to the east. The property was not examined by the field party and has been described by Rupert (1979, p.119) as follows:

"Trenching and stripping of the Figgus vein was done by Wawa Gold Fields Ltd. prior to 1934. A plan dated August 10, 1934 by A.C. Melkman shows that the main "A" vein or Figgus vein was stripped for over 140 feet and two parallel veins on the strike extension to the south were stripped for 75 feet and 55 feet. The veins strike about 117°, dip 30° to 50° northeast and have an average width of about 2 feet. At the northwest end, on the claim boundary, a segment with a strike of 150° is nearly 6 feet wide in a 40 foot lenticular section. Several spectacular assays were reported from sampling there. Assay values ranged from \$0.70 across 24 inches to \$262.85 across 18 inches. Most values are in the range of \$4 to \$10, presumably with gold about \$20.50 per ounce in 1934,

but possibly at \$35.00."

Frohberg (1935, p.76) reported the "A" vein or Figgus Vein carries pyrrhotite, pyrite, chalcopyrite, sphalerite and galena in a gangue of quartz, carbonate and tourmaline. He reported that this vein is 2 to 3 feet wide. He also reported that Vein "C" parallel to Vein "A" is mineralized with pyrite, pyrrhotite and chalcopyrite.

All major exploration efforts have concentrated on the "A" Vein or Figgus Vein and were completed prior to 1934.

The property was originally staked in the first gold rush of 1897 however there is no record of any work being completed on the property. The property was restaked in the 1930's and an inclined shaft sunk to a depth of 70 feet on the Figgus Vein. Drifting on the vein has taken place (Frohberg 1935, p.76). Two adits one at 48 feet and the second at 115 feet below the shaft collar have been completed (Rupert 1979, p.120; Frohberg 1935, p.76). The lower adit is reported to be 100 feet long (Frohberg 1935, p.76).

Rupert (1979, p.120) using available maps on the workings interpreted that the veins were either offset to the right of each other *en echelon* or as a continuous vein with alternating north and northwest-trending segments. Rupert (1979, p.120) interpreted the north-south vein segments to plunge steeply east.

A parallel vein up to 6 feet wide is reported to extend along a creek bed to the outlet of Stanley Lake (Rupert 1979, p.120). The diorite to granodiorite wall rocks are sheared up to widths of 2 to 5 feet from the vein.

The property was restaked by Pango Gold Mines Limited and is now part of the Citadel Gold Mines Incorporated holdings. There is no record of work having been completed on the property by the current owner.

CONSOLIDATED BELLEKENO MINES LIMITED (43)

New Campbell Island Mines staked the Stenaburgh Vein in Rabazo Township in 1961 and optioned the ground to Consolidated Bellekeno Mines Limited in 1962. Several claims of this group were within the limits of McMurray Township even though the bulk of the claim group lies outside the township. The company completed a magnetic survey, geological mapping and sampling. Most of the work lays in the adjacent township and the reader should refer to Massey (1985, p.69) for more data.

CONSOLIDATED MINING AND SMELTING COMPANY OF CANADA LIMITED (44)

The Consolidated Mining and Smelting Company of Canada Limited completed one deep diamond drill hole in 1964 to test the Wawa Creek Lineament. The hole was drilled on claim 67695 to a depth of 1059 feet. One sample from the core assayed 0.005 ounces Au per ton and all others were trace to nil (AFRO, Toronto). No further work was reported on the property. The drill log indicates metadiorite intruded by lamprophyre as the dominate lithology (AFRO). Mapping has suggested the area is underlain by intermediate to felsic tuffs and not diorite.

CONSOLIDATED MORRISON EXPLORATION LIMITED (45)

Consolidated Morrison Exploration Limited completed an airborne magnetometer survey and a radiometric survey in the northeast corner of the township. The company noted a pronounced circular aeromagnetic anomaly associated with the Firesand River Carbonatite. Radioactivity, particularly that due to thorium, is noted in association with the carbonatite. No follow-up work was reported.

COOPER MINE AND GANLEY VEIN (42B)
(SEE CITADEL GOLD MINES INCORPORATED)
CORA GOLD MINES LIMITED (42)
(SEE CITADEL GOLD MINES INCORPORATED)
DARWIN GOLD MINES LIMITED (47A)
(SEE DUNRAINE MINES LIMITED)
DEEP LAKE GOLD MINE LIMITED (46)

The Deep Lake Gold Mines Limited vein strikes 320° and dips 33° NE and has been traced for 600 feet on surface (Frohberg 1935, p.81). The host rock is Jubilee Tuff of intermediate composition. The vein is described as having an average width of 18 inches and consists of fine-grained bluish white quartz with minor pyrite, pyrrhotite, chalcopyrite, sphalerite and galena (Frohberg 1935, p.81). The native gold is usually very fine-grained but locally is very coarse and associated with galena and sphalerite.

Rupert (1979, p.101) described the wall rocks as dacite lavas and breccias cut by grey diorite dikes of the Jubilee Granitic Stock and one lamprophyre dike 1.5 feet wide. He described the vein walls as sharp and unshered and the vein as rusty sugary quartz with only traces of arsenopyrite and chalcopyrite.

Rupert (1979, p.100) took 6 channel samples across the vein and 5 grab samples from the stock pile. All samples ran less than 0.03 grams Au per ton (Rupert 1979, p.100). Rupert (1979, p.101) reported the presence of anomalous thorium in the area.

The mine site was mapped by the field party. Favourable indications such as sulphide bearing quartz veins and carbonate alteration for gold mineralization were not noted.

The original discovery was made in 1934 and in 1936 W.J. Hocking, Manager of Minto Gold Mines Limited and his partner J.C. Canfield, who was associated with the Van Sickle Mine, opened the Deep Lake Mine (Rupert 1979, p.99). A small 20 ton per day amalgamation mill was constructed and production started with collaring of the shaft (Rupert 1979, p.99; MDIR, Toronto). Production totalling 1,633 ounces Au and 57 ounces Ag resulted from milling in 1936, 1937, 1938 and salvage in 1943 (MDIR, Toronto). The total tons treated is reported to be 2,790. Material grading less than \$14.00 per ton was reported to be stock piled (Northern Miner, January 28, 1937).

A two-compartment shaft reached a depth of 155 feet in 1937 to 1938. Shaft sinking to a depth of 200 feet and a second level were established in 1938 (MDIR, Toronto). Operations terminated in 1939.

DEEP LAKE GOLD MINES LIMITED

The property was acquired by Deep Lake Gold Mines Limited in 1938. The company prepared an underground map and collected samples. The results of this work are unknown. The company completed no additional work before its charter was cancelled in 1957 (Rupert 1979, p.100; Canadian Mines Register, Dormat and Defunct Mines). The property was restaked by P. McLean in 1964.

MRS. CARLETON BLANCHE

In 1965, under the direction of P. McLean 8 diamond drill holes totalling 2,064.2 feet were completed. There is no record as to the results of this work. The location of these drill holes are indicated in Figure 85.

GOLDEN GOOSE GOLD MINES LIMITED

In 1979, R. Rupert collected 35 representative channel samples across the Deep Lake vein at intervals of 5 to 10 feet. Values varied from the limit of detection to 0.026 ounces per ton and average 0.009 ounces Au per ton (Rupert 1980, p.1). Rupert (1980, p.4) reported that trenching, stripping and three diamond drill holes were completed. Records for this work could not be located. There is no record of work following the work by Golden Goose Gold Mines Limited in 1980. Rupert (1980, p.1) mentioned the possibility that the gold reported from the mine actually came from rock extracted from elsewhere. Surface assays obtained by Rupert (1980) support this proposal. Rupert (1980, p.6) did not find the vein to be as well mineralized as reported by Froberg (1935).

DUNRAINE MINES LIMITED (47)

Dunraine Mines Limited controls the former producing properties of Parkhill Gold Mines Limited and Darwin Gold Mines Limited and the Mariposa prospect. The present holdings were joined together in 1980.

The Darwin and Parkhill properties are part of a similar if not the same stratigraphic package that lies east and west of the Parkhill Fault. The Parkhill Fault is the southern extension of the regional Black Trout Lake Fault. Using a polymictic breccia unit as a marker horizon left-lateral offset along the diabase-filled Parkhill Fault is approximately 800 m. The recognition that the Parkhill and Darwin Mines are in the same lithologic package indicates that the vast majority of gold production south of Wawa has been recovered from a single geologic horizon. In addition, while other mines in the district such as the Jubilee and Minto have had gold production it can be argued that the funds received for this gold would not cover the development costs to recover it. On the basis of existing data, it also appears that the more productive Parkhill and Darwin Mines may not have produced revenue equal to that spent on them. This possibility is mentioned by Rupert (1979, p.105) for the Parkhill Mine. On the basis of the large volume of data on file with the Ontario Geological Survey, it appears that both properties were always suffering capital shortages which affected their development and every day operation.

Early work on the Parkhill and Darwin Mines described the gold as

occurring in epigenetic veins (Frohberg 1935). More recent work has resulted in the development of a syngenetic volcanic-fumarolic model (Studemeister 1984). Both models have merits while the author favours the first or older model there is some evidence to the contrary. Some questions will undoubtedly be answered if the underground workings become accessible to geologic examination.

DARWIN (GRACE) MINE GEOLOGY

The geology of the Darwin Mine has been discussed by Weeks (1928, p.7c, 8) Frohberg (1934a, 1935), Gledhill (1927, 1939), Collins and Quirke (1926) and Rupert (1979). Early reports on the mine describe the host rock as porphyrite (Gledhill 1927, p.32); this rock is an intermediate composition feldspar crystal tuff. North of the Darwin Mine a polymictic volcanic breccia (described as agglomerate by Frohberg (1935, p.81)) strikes 30| and dips 35|NW. The dip is reported to steepen considerably on the 3rd and 4th levels of the mine. Frohberg (1935, p.81) stated that the porphyrite (Jubilee Tuff) intrudes the volcanic rocks but admitted clasts of this rock type are present in his agglomerate units casting doubt on his suggested intrusive relationship. Intrusive relations were not observed by the author. The most complete description of the mineralization is that of Frohberg (1935, p.82, 83). He described the veins as follows:

"There are two veins at the Darwin, the Grace vein, which has a general strike of N.30|W. and a dip of 70|NE and an east-west vein dipping 40|S. Like the veins of the Parkhill mine, the Darwin veins occur along definite shear zones and consist of a succession of lenticular quartz bodies, most of which are less than 100 feet long, their width varying from a few inches to more than 5 feet. The vein quartz is of a granular type and is accompanied by subordinate quantities of carbonates and tourmaline. In contrast to the Grace vein, which is mineralized chiefly with arsenopyrite and minor amounts of pyrrhotite, pyrite and chalcopyrite, the east-west vein is practically free of arsenopyrite; pyrrhotite and pyrite are the prevailing sulphides. As a rule, native gold is visible in ore containing more than half an ounce of Au per ton. Spectacular coarse gold has been found repeatedly in the Grace vein.

Underground operations have located three ore zones along the Grace vein and two ore shoots on the east-west vein. The only ore zone extending to the surface was the original discovery of the Grace vein, on which the old inclined shaft was sunk. The quartz bodies of the east-west vein apex a short distance above the 6th level and above this horizon the vein is represented by a barren shear zone devoid of any quartz or mineralization. The ore shoots of the Grace vein have a rake of about 60|S. The ratio of horizontal to vertical extent of the ore bodies of the Grace vein was found to be approximately 1 to 3, the horizontal length being about 100 feet. Below the 500-foot horizon, gold values in the Grace vein showed a general decline below the economic limit, although the vein as such, continues structurally unaltered.

As a rule, junctions of parallel branches of the gold-bearing shear zones are favourable locations for ore concentrations, whereas intersections are without any noticeable enrichment."

Using available plan maps, Rupert (1979, p.115) suggested that the ore in the Grace Vein extends only as far north as the agglomerate (polymictic breccia). He also reported that diorite rocks are common on the old waste piles of the mine suggesting that in the deeper parts of the mine both the Grace and Nyman Veins are in diorite of the Jubilee Stock. Rupert (1979, p.115) reported a diorite plug southwest of the mine and that numerous diorite dikes occur in the area.

Table 32 gives the estimated gold production from the mine. In addition, the mine is reported to have produced 1,363 ounces of Ag (MDIR, Toronto).

Recent work by Studemeister (1984b) and the author indicated the Darwin Mine is in tuffs, feldspar crystal tuffs and lapilli tuffs. The mine developments are in the Jubilee Tuffs south of a polymictic volcanic breccia which in turn lies just south of the contact of the tuffs with the Jubilee Stock.

Studemeister (1984b, p.4) described the Grace Vein as a horizon of clastic and exhalative metasedimentary rocks approximately 6.1 m wide occupying a paleo-gully on the flank of a volcano. He reported that the horizon is traceable for 762 m even though offset by small diabase-filled faults. The horizon is described by him as a schistose assemblage of lithic wacke, pelitic tuff and cherty breccia flanked by feldspar crystal lapilli tuff (Studemeister 1984b). Studemeister (1984b) described the horizon as poorly bedded and containing rounded lithic clasts of tuff, wacke and siliceous rock. Studemeister (1984b, p.4) reported that the gold occurs as irregular pockets in an arsenopyrite-bearing pelitic tuff containing lenses of sugary quartz. Studemeister (1984b) stated that the horizon is similar to the Parkhill horizon with the gold occurring in both quartz lenses and matrix in widths from 0.3 to 3.0 m. The gold is concentrated in paleo topographic irregularities or troughs and slump channels. Studemeister (1984b, p.5) interpreted old records to indicate the Grace horizon merges with the faulted extension of the Parkhill horizon on the 182.9 m (600 foot) level.

Studemeister (1984b, p.5) considered the gold to be syndepositional with the enclosing tuffs. The gold was deposited as exhalite and has been slumped or been transported into its present setting along paleochannels on the flank of the volcano.

The Grace horizon is classified by the author as fine-grained tuffs. The polymictic breccias north of the Darwin Mine and north of the Parkhill Mine are limited in distribution and are considered by the author and Studemeister (1984b) to represent debris flows occupying paleochannels on the slope of a volcano. The author has proposed that the clastic metavolcanic rocks and felsic flows in the Stanley Lake area also occupy paleo channels on the slopes of a volcano. The structurally high level Jubilee Stock occupies the core of this former volcano and is thus closely tied to structural development of zones favorable to gold mineralization south of Wawa Lake. The cross cutting and branching nature of the gold-quartz mineralization suggests to the writer that the gold ore occurs in quartz veins and that the gold was not syndeposited as an exhalite with the enclosing tuff. This veining may be related to emplacement of the Jubilee Stock which intrudes the Jubilee Tuff.

PARKHILL MINE GEOLOGY

The Parkhill Mine was the largest gold producer in the area south of Wawa Lake. A large number of reports, memorandums and letters are present in the files of the Ontario Geological Survey concerning this property. In spite of the large volume of data, geologic maps of the workings are unavailable and may never have been prepared.

A selected bibliography on the mine is Fabian 197; Froberg 1934b, 1935; Hesse 1938; May 197; Moore 1931; Reid 1938; and Rupert 1979. A polymictic breccia north of the Parkhill mine is thought to be stratigraphically equivalent to a polymictic breccia north of the Darwin Mine. This unit has been used to determine offset along the Parkhill Fault. The Parkhill mine is located within Jubilee Tuff above a polymictic breccia lying close to the contact with the Jubilee Stock. On the former Parkhill property other veins have been reported to be present. These veins are the Blackinton, Mariposa, Corona, Florence and Mickelsen (Rupert 1979, p.105; Hesse 1938, p.6). The author is unsure of the location of some of these vein structures.

Froberg (2935, p.78, 79) described the veins at the Parkhill Mine as follows:

"Four of the veins have strikes ranging from N60° E. to due east; one strikes approximately N.20° W. The dip of the veins varies from 30 to 60°, the average being about 45°. Only three of these veins were located on the surface, the other two being discovered during underground work. The north-south vein has not been found to extend above the 9th level, although its barren shear zone seems to continue toward the surface.

The east-west veins form a system converging toward the west. No.1 vein, on which the shaft was started, appears to be the most persistent; the other veins are headed to join No.1 vein and disappear in the western part of the mine. Similarly, the east-west veins seem to converge downward, as only two of them have been definitely recognized in the deep levels. Near the north-south vein, the east-west veins show a slight deflection, which was probably caused by a late fault zone accompanying the north-south vein in the hanging wall.

The veins consist of a succession of lenticular quartz bodies, which occur along shear zones. The horizontal extent of the quartz lenses varies greatly and in some places reaches 125 feet; the width of the quartz averages little over 2 feet, with a maximum of about 6 feet. There are three major ore zones along the east-west vein system and one ore shoot on the north-south vein. The axes of the ore zones pitch at an angle of about 60° to the right of an observer looking down the dip of the vein. Thus, the steeper of the east-west veins rake toward the west and those on the north-south vein to the south. As compared with their relatively short horizontal length, nearly all the ore shoots are remarkably persistent in vertical dimension. The so-called "West" ore shoot was followed from the 3rd level downward to the 9th level, where it was found to be cut off by a wide diabase dike. As a rule, junctions of two or more veins are favourable locations for ore bodies. In a few cases, "rolls" or minor foldings of the veins seem to have controlled the mineralization of certain quartz lenses.

The mineralization of the veins consists essentially of pyrite, pyrrhotite, chalcopyrite and gold. In general, the quartz carries little visible gold. Pockets containing spectacular aggregates of coarse gold have been found occasionally and some of them are said to have yielded more than 400 ounces of gold."

Rupert (1979, p.107, 108) examined the available mine plans and concluded the following:

"The ore zones are a series of discontinuous lenticular quartz veins in narrow shear zones. The mine plan (partially reproduced on Map p.828, Rupert 1975) shows the shear zone exposed at surface as an arcuate structure with a strike of 036° and dip of 38° south at the west end and a strike of 90° and dip of 38° at its eastern extremity. Underground, additional shear zones are present, progressively displaced to the right of the previous shear zone. The average strike direction of the series of shear zones is about 075° to 080°, but it consists of individual long segments with a strike of about 055° to 060°, displaced to the right by shorter segments with azimuth directions of 090°, or displaced by an echelon gap. The curving open Z-shaped structures formed by the 090° segments and the overlapping of veins formed by an echelon arrangements both plunge at about 35° with an azimuth of 195°. The right hand displacements have horizontally measured magnitudes of 20 to 150 feet.

Ore shoots consisted of lenticular quartz veins developed either on shear segments with low dips and an azimuth close to 90° or on overlapping on echelon edges of shear zones. The best ore shoot was 1,000 feet in plunge length, 140 feet in horizontal length and less than six feet wide. At the bottom east end of the mine, a shoot with a plunge length of over 650 feet and 250 feet in horizontal length was mined. Production figures for individual stopes indicate that the best ore grade was in the central part of the larger ore shoots, possibly because wall rock dilution was less in these wider parts. In general, the best ore shoots, with stope grades of up to 1.0 or 1.5 ounces per ton, were those with ratios of plunge length to horizontal length of about 8:1 and these ore shoots were on the gently dipping 090° azimuth sections of Z-shaped folds. Overlapping segments of an echelon shears had more equidimensional form and lower stopping grades of 0.2 to 0.4 ounces per ton.

A transverse vein extending several hundred feet into the footwall was mined between the ninth and fifth levels. It had a strike of about 140° and dipped 48° east. According to Froberg, the pitch of ore shoots on this vein was about parallel to its intersections with the main shear zone, but mine plans and records indicate that the ore shoots were not necessarily at the intersection. The best stopping grades on this vein were less than 0.45 ounces per ton and generally less than 0.25 ounces per ton."

Rupert (1979, p.109) considered most of the Parkhill Mine to lie within intrusive diorite, however, recently stripping of the vein by Dunraine Mines Limited indicates the vein to be in thinly bedded wackes showing excellent graded bedding and good primary slump features. The Parkhill Vein at surface appears to be concordant with primary bedding. The presence of these primary sedimentary features has prompted a new interpretation for the origin of the Parkhill Vein by Studemeister (1984b).

The metasedimentary rocks are referred to as the Parkhill Horizon by Studemeister (1984b, p.2) who estimated the zone to be 15.2 m wide and dipping 40 to 50°. Studemeister (1984b, p.2, 3) interpreted the zone to extend from the former Van Sickle Mine to the Darwin Mine, an original distance of approximately 1.6 km before being offset by the Parkhill Fault. The Parkhill Horizon consists of lithic wackes and sugary quartz lenses and clastic metavolcanic debris (Studemeister 1984b, p.3). He reported the presence of channels 6 to 2.1 m wide in the wackes filled with quartz lenses with accessory pyrite, pyrrhotite and chalcopyrite (Studemeister 1984b). Gold occurs in the quartz lenses and the matrix only locally contains gold (Studemeister 1984). The rocks enclosing the Parkhill Horizon were described by Studemeister (1984b, p.3) as matrix-and clast-supported breccias consisting of rounded to angular clasts in a clastic matrix. Scattered siliceous units are reported by him to be anomalous in gold content.

The Parkhill Horizon is interpreted by Studemeister (1984b, p.3) to be a metasedimentary rock that was deposited on the flanks of a volcano with gold-bearing quartz lenses occupying channels in the metasedimentary rocks. He relates the gold-bearing zones to the slump or erosion and transportation of volcanic-fumarolic gold-bearing deposits from higher up on the flank of the volcano and redeposition at lower levels. This model was also mentioned in the discussion of the geology of the Darwin Mine.

The quartz forming the Parkhill Vein, where examined by the author, has the appearance of a typical Archean gold-quartz vein at surface and on the first level. The concordancy with the metasedimentary rocks may be fortuitous. If subsequent work supports the model of Studemeister (1984b) it is worth remembering that the north-south vein which is oblique to the Parkhill Vein is also gold-bearing and had supplied ore. This would suggest two periods of ore formation, one epigenetic and one essentially syngenetic. A resolution of this problem will have to await the dewatering and examination of the abandoned workings.

A gap exists in the underground workings between the Parkhill Mine and Van Sickle Mine to the east. As pointed out by Rupert (1979, p.110) this area may offer good exploration potential. As mentioned under the discussion of the Darwin Mine geology, the polymictic breccia probably occupies a paleochannel on the flanks of an Archean volcano. The granular grey white quartz of the Parkhill Vein gives a distinct odor of garlic or methane immediately upon breaking.

The former Parkhill Mine was purchased by J. Kosa in 1941. The Darwin Mine property was purchased by J. Kosa from W. Weiss on October 24, 1980 who retains a 5% interest in the property. The company optioned the former Van Sickle Mine on October 31, 1980 and dropped it on November 1, 1982. The former Mariposa property lies within the holdings of Dunraine Mines Limited. The company completed line cutting and geological mapping in 1980 and in 1981 dewatered the Parkhill Shaft to the second level (Plate 43). The shaft was allowed to fill before underground examination could begin. The company completed extensive diamond drill programs around the old Parkhill Mine site in 1980 and along the Darwin Shear in 1981. Additional surface diamond drilling was completed in 1982 and 1983 at several sites on the Darwin property. Records (AFNO) for the 1980, 1981 and 1982 drilling indicate 17,373 feet of drilling was completed. Logs for the 1982 and 1983 diamond drilling are unavailable. The Parkhill shaft was dewatered to the second level in 1982 and then allowed to flood. Figure 88 is a schematic sketch of the Dunraine Mines property showing position of the diamond drill holes. Table 33 gives the amount of diamond drilling completed on the property and those intersections greater than 0.10 ounces Au per ton.

Production recorded from the Parkhill Mine totals 54,301 ounces Au and 2,896 ounces Ag from 128,778 tons of ore (MDIR, Toronto). The best ore host was 1000 feet in plunge length, 140 feet in horizontal length and less than 6 feet wide (MDIR, Toronto). Best stopes grades were between 1.0 and 1.5 ounces per ton.

DARWIN (GRACE) GOLD MINES LIMITED (47A)

Mining claim M 1032 was staked in 1900 by A.B. Beckinton and sold to J. George who is reported to have discovered the Grace Vein (Rupert 1979, p.111). Mr. George sold the property to the Algoma Commercial Company a subsidiary of the Lake Superior Corporation controlled by F.N. Clergue (Rupert 1979, p.111).

ALGOMA COMMERCIAL COMPANY

Shaft sinking began in 1900 by the Algoma Commercial Company and in 1902 6,097 tons were run through a 10 ton per day stamp mill. The shaft was sunk at 67° to the east to a depth of 304 feet with levels at 100, 200 and 300 feet (MDIR, Toronto). Work ceased when the company passed into receivership in 1903.

LEPAGE GOLD MINING COMPANY

Between 1907 and 1910, 4,260 tons of ore were produced by the LePage Gold Mining Company before production was terminated (Rupert 1979, p.111). Between 1910 and 1927, the property was owned by the Grace Mining Company, the A-Gold-Ma Mining Syndicate and a Pittsburgh syndicate mentioned by Collins and Quirke (1926) (Plate 44). Minor salvage production occurred in 1923 and 1925 before the property was transferred by A. Gibson and M.B. Webber to the United Algoma Mines Limited in 1925 (Rupert 1979, p.111). A number of reports on the property exist that were prepared when the property was under control of Grace Mining Company (AFRO, Toronto). The property is sometimes referred to as the Grace

Mine. Osler (1925, p.1) mentioned that the Grace vein was stripped and trenches and three diamond drill holes completed by the Canada Gold Syndicate prior to 1925.

POWER AND MINES SYNDICATE

The property was optioned to the Power and Mines Syndicate in 1926 and its successor the Power and Mines Corporation Limited which continued the shaft to 440 feet and completed some lateral work (MDIR, Toronto). The company produced 750 tons of low grade ore in 1930 before being closed down (Rupert 1979, p.112). The property reverted back to United Algoma Mines Limited which was reorganized as Darwin Gold Mines Limited in 1934 (Rupert 1979, p.112). Weeks (1928, p.7c) reported that the Nyman vein, which occurs on the property, was found in 1927 by an employee of the Power and Mines Syndicate and had been stripped. Weeks (1928, p.7c) reported that the Nyman vein strikes 70° west of north.

DARWIN GOLD MINES LIMITED

In 1934, the inclined shaft was continued by Darwin Gold Mines Limited to 500 feet and a new vertical shaft sunk to 830 feet with levels at 600, 700 and 800 feet (MDIR, Toronto) (Plate 42). The two shafts were connected on the 3rd, 4th and 5th levels. Between 1935 and 1937, the company milled 34,421 tons of ore before going bankrupt in 1937 (Rupert 1979, p.112, MDIR, Toronto). The company was reorganized into New Darwin Gold Mines but completed no additional work.

In 1938, the property was sampled by Erie Canadian Mines Limited but no work was completed by this company (AFRO, Toronto).

In addition to the shafts, the mine has undergone 10,400 feet of drifting, 2,900 feet crosscutting and 4,000 feet of raising (MDIR, Toronto). Some clean up and salvage was completed in 1940 and 1943 and the property passed through several parties before ending up under control of W.A. Hesse (Rupert 1979, p.112). Mr. Hesse sold the surface rights in 1967. The mining rights passed to W. Weiss who sold them to Dunraine Mines Limited in 1980 (Rupert 1979, p.112; MDIR, Toronto; H. Koza, Dunraine Mines Limited, personal communication 1983). The charter of New Darwin Gold Mines was cancelled in 1949 (Canadian Mines Register, Dormant and Defunct companies, p.272).

MARIPOSA PROSPECT (47B)

The Mariposa prospect is located within several metres of the Gold Mine road that connects most of the gold mines and principal prospects south of Wawa. Several quartz veins occur near the shaft at the prospect and similar quartz veins striking parallel to those at the shaft occur close by and along strike. Similar veins are found up to 1.6 km on strike southeast of those at the shaft (Rupert 1979, p.135). The quartz veins have a strike parallel to the Parkhill Fault and may occupy a prominent structural trend parallel to the fault.

There is little in the written records or on file of the Ontario Geological Survey regarding work on the Mariposa prospect or nearby vein structures.

Rupert (1979, p.135) reported that just north of the Mariposa Shaft a 20 foot pit exposes an 8 foot wide quartz vein. This vein strikes 52° and dips 76° NW. Southeast of the shaft and east of the Gold Mine road trenching exposes the Mariposa Vein. At this position, the vein strikes 135° and has a dip 80° NW to vertical (Rupert 1979, p.135).

The vein is described by Gledhill (1927, p.45) as follows:

"The vein quartz is glassy, with ankerite as the main gangue and pyrite as the chief sulphide mineral. It is reported that the better gold content in the vein was found west of the shaft near the vein intersections."

Gledhill (1927, p.45) described a second vein located 0.8 km southeast of the shaft as follows:

"A large quartz vein, several feet wide, extends northwestward across claim No.3,375. This vein is one of the most continuous in the camp and passes at the northwest end on to the Mariposa group; its commercial value is not known at present, but in the sections examined it had very few sulphides."

The precise location of the veins described by Gledhill is uncertain.

Neither Rupert (1979, p.137) nor the field party located the veins described by Gledhill (1927).

Approximately 0.8 km southeast of the Mariposa Shaft, Rupert (1979 p.137, 138) reported the presence of felsic grey coloured metavolcanic breccia containing between 3 and 5% pyrite and pyrrhotite with traces of chalcopyrite.

Quartz veins 5 and 12 feet wide on strike with the Mariposa Vein are present at the north end of a small pond approximately 1.6 km southeast of the shaft (Rupert 1979, p.138). These veins dip 45 to 55° NE (Rupert 1979, p.138).

EDEY GOLD MINING COMPANY

The original claims for the Mariposa prospect were staked by A.B. Blackinton and W.H. Lewis early in 1898 (Boyd 1901, p.138; Rupert 1979, p.135). Several claims staked by the above men were purchased by the Edey Gold Mining Company of Ottawa Limited who stripped the vein for several hundreds of feet southeast of the present Gold Mine road. The vein was known as the Blackinton Vein at this time (Boyd 1900, p.112). This company excavated several 25 foot deep pits in 1899 and in 1900 sank a 33 foot shaft (Boyd 1900, p.112; 1901, p.139).

MARIPOSA GOLD MINING COMPANY

The Mariposa Gold Mining Company acquired claims northeast of the Edey Gold Mining Company of Ottawa Limited group in 1902 and in 1903 sank the 208 foot Mariposa shaft inclined at 80° NE in the footwall of the vein (Boyd 1904, p.46; Rupert 1979, p.136). Levels at 100 and 200 feet were established and crosscuts driven east to the vein (Boyd 1904, p.46). In 1904, production of approximately 18 ounces Au valued at \$347.00 was

produced from 9 tons (Rupert 1979, p.136; MDIR, Toronto).

By the 1920's the Mariposa claims had been forfeited to the crown and restaked. Some of these claims were acquired by Parkhill Gold Mines Limited but there is no record of work being completed on them by the company.

DUNRAINE MINES LIMITED

Dunraine Mines Limited completed one diamond drill hole in 1980 through the Mariposa Vein just north of the shaft. This drill hole was drilled to 255 feet and failed to intersect the vein. The reader should refer to Figure 88 and hole 11 for the location of this drilling.

PARKHILL GOLD MINES LIMITED

The Parkhill Vein was staked by the Michael Syndicate or Wawa Syndicate and eventually transferred to Cooper Gold Mines Limited a subsidiary of the Pioneer Mining Corporation Limited.

COOPER GOLD MINES LIMITED

The Parkhill Mine site was first known as the Longbottom or Trout Creek property (Robinson 1935, p.112). Rupert (1979, p.106) examined maps prepared by Boyd (1899) and concluded that the Parkhill vein was not covered by staking during the initial rush for gold into the area. Claims south of the Parkhill mine site were referred to as Longbottom and were apparently staked to cover the Mariposa vein (Rupert 1979, p.106).

The Pioneer Mining Corporation Limited optioned several properties from the Michael Syndicate in 1926 and work on them was completed by its subsidiary (Cooper Gold Mines Limited) in approximately 1927. The Pioneer Mining Corporation Limited had control of the Minto, Jubilee, Cooper and Trout Creek properties in 1926-1927 and completed surface work and diamond drilling on them (Gledhill 1927, p.34).

The Trout Creek property of Pioneer Mining Corporation Limited is the present Parkhill Mine property (Gledhill 1927, p.36). The company completed 3 diamond drill holes of approximately 400 foot depth from the south side of Trout Creek (Moore 1931, p.39). Gledhill (1927, p.36, 37) indicated this drilling was to test northeast-striking quartz lenses in sheared diorite. The veins were reported to have a shallow dip to the south (Gledhill 1927, p.37). It is uncertain whether this drilling intersected the Parkhill Vein as records for this work could not be located by the author.

PARKHILL GOLD MINES LIMITED

Parkhill Gold Mines Limited was incorporated in April 1929 and took over the Trout Creek property from Cooper Gold Mines Limited (Canadian Mines Handbook 1935, p.193). Inclined shaft sinking at 40 to 42° began on May 1, 1930 (Moore 1931, p.39). Production began in July 1931 and by 1938 the shaft had reached 1,909 feet inclined depth, or 1,278 feet vertical depth, with 14 levels (MDIR, Toronto). Production continued to January 1938 when Parkhill Gold Mines Limited went bankrupt (Rupert 1979,

p.107; Canadian Mines Handbook 1938, p.215-216).

WARD LAKE GOLD MINES LIMITED

Ward Lake Gold Mines Limited was organized in May 1938 to take over the former Parkhill Gold Mine (Canadian Mines Handbook 1939, p.278). Their is no record of work on the property by this company and its charter was cancelled in 1948 (Canadian Mines Register of Dormant and Defunct Mines p.403).

Records in the MDIR Toronto indicate the property was once owned by Devon Gold Mines Limited. There is no record of such ownership in the Canadian Mines Handbook for the years 1940, 1941, 1942 but it appears the company purchased the Parkhill Mill (Canadian Mines Handbook 1941, p.51).

Minor gold production reported from the property in 1940, 1942, 1943 and 1944 is presumed to be from clean-up and salvage operations.

There is no record of production or development in subsequent years. The former Parkhill Mine is now part of the Dunraine Mines Limited holdings which has undertaken extensive trenching, stripping and surface diamond drilling.

EDINA PROPERTY (48)

This property is also referred to as the Adina property in some reports. The property is located on the east side of Leroy Lake. The field party encountered numerous pits in sulphide facies iron formation where this property is located. Four grab samples of sulphide facies iron formation collected by the field party returned only traces of gold.

Dominantly intermediate to mafic metavolcanic rocks in which quartz-feldspar porphyry and granitic dikeing increases as one moves east towards the Whitefish Lake Batholith were encountered. Gledhill (1937, p.4, 5) indicated the presence of three bands of iron formation, one of major and two of minor importance, on the property. Close to Leroy Lake the iron formation approaches 200 feet in width but decreases in thickness to the east. Sketch maps of the major unit of iron formation prepared for Nakusp Resources Limited and Welcome North Mines Limited indicate that sulphide facies iron formation forms the north part of the iron formation unit and thin bedded chert and magnetite the south part. Using facies distribution as a facing indicator the stratigraphy most likely faces south. Mapping by Watson (1983) indicated the main iron formation dips south 30 to 40° and strikes approximately 110° for approximately 600 m.

Rupert (1979, p.143) reported that the iron formation terminates just east of Leroy Lake. The Firesand River Fault passes along Leroy Lake and the termination may thus be fault controlled.

The original property was staked or acquired in 1934 by J.H. Teare (Gledhill 1937, p.6).

EDINA GOLD SYNDICATE

The Edina Gold Syndicate completed extensive sampling and trenching on the property in 1936 (Gledhill 1937a, p.6). Under the heading of Edina Gold Syndicate, Teare (1936) reported 0.264 ounces Au per ton over 115 feet in Trench 1, Vein 1; 0.220 ounces Au per ton over 18 feet in Trench

1, Vein 1 and a estimated 0.173 ounces Au per ton over 54 feet in Trench 5, Vein 3. It is unknown as to what showings Teare (1936) referred to. Gledhill (1937a, p.4) reported that veins 1, 3 and 4 are iron formation on Teare's sketch map which is no longer available.

ASARCO COMPANY OF CANADA LIMITED

Asarco Company of Canada Limited examined the property in 1975 when the showing was covered by claims owned by C.E. Nyman. No work was done.

NAKUSP RESOURCES LIMITED

The property was staked in 1982 and in 1983 by J.R. D'Oliveira and R.D. Henderson. An additional 3 claims staked by E. Frey were later added to the group. Nakusp Resources Limited gathered chip and grab samples from the trenches in the iron formation. The best value obtained was 0.06 ounces Au per ton (Watson 1983, p.13). Most values reported by the company were 0.001 ounces Au per ton. A quartz vein cutting intermediate to mafic metavolcanic rocks north of the iron formation was channel and grab sampled. Three samples returned 0.001 ounces Au per ton and one grab sample returned 0.132 ounces Au per ton.

No additional work was reported.

WELCOME NORTH MINES LIMITED

The property was sampled by MPH Consulting Limited for Welcome North Mines Limited in late 1983. The highest value obtained by the company on 52 samples was 0.04 ounces Au per ton (Brereton 1983, p.1). Most gold values reported range between 0 and 40 ppb (Brereton 1983, p.1). No additional work is reported. Recent sampling has thus failed to support the values reported by Teare (1936).

FIRESAND RIVER CARBONATITE

GOLDEN GOOSE MINES LIMITED (46)

(SEE DEEP LAKE GOLD MINES LIMITED)

GOLDEN REED GOLD MINES LIMITED (49)

The former Golden Reed Mine is located approximately 500 feet northeast of Reed Lake. Two shafts are indicated to be present on the property (Rupert 1975) however only one could be located by the field party. Considerable stripping and trenching is present in the area. The main workings appear to be at the base of a low northeast-trending ridge. Considerable machinery and equipment remain at the site (Plate 45, 46). The host rock to the quartz veins appears to be a very fine-grained granodiorite, possibly related to the Jubilee Stock. The shaft appears to have been sunk along the contact of granodiorite with intermediate to mafic metavolcanic rocks. The shaft workings were inaccessible to examination. A short adit into the ridge above the shaft examined by the field party indicated an irregular quartz vein system with a general trend of 055 and a steep dip of approximately 75 N. The rocks exposed in the partly covered shaft appeared sheared. The vein consists of white quartz with very minor pyrite.

The property was staked somewhere in the period of 1900 to 1907 and underwent development in 1908 (Rupert 1979, p.128). An inclined shaft at 60' was sunk to a depth of 46 feet in 1908 and a short 20 foot adit driven northwest from the collar of the shaft into the adjacent ridge. The shaft was sunk at the point where veins exposed in the adit are intersected approximately at right angles by another quartz vein.

Production of 6 ounces Au from 3 tons of ore was recorded (MDIR, Toronto).

The second shaft, not located by the field party, is described by Rupert (1979, p.129):

"A second inclined shaft is located about 700 feet southeast of the one described above. It was sunk on the dip of a two foot wide vein which strikes 135° and dips 60°N. From the size of the shaft and spoil dump, the depth of the shaft is estimated at 35 feet deep.

The vein is quartz with no significant sulphide mineralization evident. Wall rocks are granodiorite and grey, pyritic, intermediate volcanic rocks with salmon-pink alteration on joints. The intermediate composition volcanic rock may be from a xenolith in the granodiorite."

**GRACE GOLD MINES LIMITED
(SEE DARWIN GOLD MINES LIMITED).
HENDERSON PROPERTY (44)**

Three claims numbers S S M 21835 thru S S M 21837 were staked by S. Henderson in April 1931 on the east side of Wawa Creek. The location of these claims is approximately that of Consolidated Mining and Smelting Company of Canada Limited (44). There is no record of work being completed on these claims.

HILLSIDE PROSPECT (50A, 50B)

Little information is available on this property. Surface outcrops and the main adit were examined by Rupert (1979, p.116, 117) and he described the geology as follows:

"Between 1934 and 1936, an adit on the property (Location 50A) was driven in a straight line along the approximate contact between basaltic lava flows and an intrusive quartz porphyry intrusion, as indicated at reference point 13 on Map F.628 (Rupert 1975). Along its length of 710 feet, this adit is alternately in each of the above rock types. Minor randomly oriented shear zones or faults with quartz veins to 3 inches wide are present at places. The portal is located at a shear zone which dips 72° northeast. One chloritic shear zone with a width of 3 feet, a strike of 036° and a dip of 32° southeast was encountered in the adit and short drifts were driven along it. About 5% of quartz veins are present in this shear. Sacks were taken down for 29 feet in a 3 foot wide diabase dike which crossed the adit near its south end."

Above an adit (Location 50B) whose entrance is just north of Wawa Lake Rupert (1979, p.118) described the veins as follows:

"Above this adit, trenching on the hill exposes a 3 inch to 12 inch wide quartz vein along a length of nearly 500 feet. It strikes 043° and dips 80°N. A second vein strikes 053° and dips 85°N. The latter vein is located 180 feet southeast of the south end of the former vein.

Wall rocks at this location consist of interbedded quartz eye porphyry rhyolite tuffs, chloritic tuffs and greywackes. Bedding attitudes are quite variable."

The early history of this property is unknown. Prior to 1926 this property was apparently part of one of the Johnson Mining locations surveyed in 1871. Vague reference to prospecting were made by Bell (1898). The claims reverted to the crown and were staked in 1926 and again in 1933 (Rupert 1979, p.116). Hillside Gold Mines Limited was incorporated in August 1934 and an adit driven 400 feet (Location 50A) under the direction of D.S. Baird (Sinclair 1934, p.99).

In 1935, the adit reached 790 feet and 49 feet of crosscutting was completed (Sinclair 1935, p.112). The above work was on claim S S M 4925. A 52 foot adit on claim S S M 7367 driven by persons unknown was extended to 108 feet (Sinclair 1935, p.112).

Rupert (1979, p.118) reported the portal of this shorter adit to be at the base of a northwest facing cliff several hundred feet inland from Wawa Lake. He reported the adit was driven into the cliff face at 35° and then turned to drift northeast. The adit was not examined closely by Rupert (1979) and is indicated by location 50B on the map.

The adit at location 50A was extended to 890 feet and 1,935 feet of underground diamond drilling completed in 1936 (Sinclair 1936, p.143). A 20 ton per day amalgamation mill was placed in operation during 1936 and 200 tons of ore was treated but results are unknown (MDIR, Toronto). Operations were continued by Hillside Gold Mines Limited until March 1937 when the company went bankrupt (Sinclair 1938, p.82). Akbar Gold Mines Limited was incorporated in November 1937 and took over the property (Sinclair 1938, p.82). There is no record of work by the company. The company charter was cancelled in 1951 (Canadian Mines Register Dormant and Defunct Mines p.11).

HORNBLENDE PROPERTY (42C)

(SEE CITADEL GOLD MINES INCORPORATED)
JUBILEE GOLD MINE
(SEE CITADEL GOLD MINES INCORPORATED)
JUDITH IRON RANGE (51)

The Judith Iron Range is located in the northeast corner of McMurray Township. The iron formation caps a thin intermediate to felsic crystal tuff unit and marks the top of subcycle one volcanism. The Judith Iron Range may be the western extension of the Kathleen Iron Range. Both the Kathleen and Judith Iron Ranges occur at the same stratigraphic position in the volcanic stratigraphy.

The iron formation does not exceed 61 m in width and on the basis of geophysical data and records on file the strike length may approach 1220 m (AFRO, Toronto). The northern part of the iron formation consists of thin bedded laminated gray to black chert. The southern part of the iron formation consists of sulphide facies iron formation which is locally massive. The distribution of facies, chert to the north, sulphide to the south, suggests the iron formation faces north, consistent with pillow facings along Highway 101 to the north.

The iron formation drilled by Algoma Ore Properties Limited on anomaly 30 (see Algoma Ore Properties 38C-2) may be the western extension of the Judith Iron Range.

Extensive pitting was encountered by members of the field party on the west shore of an unnamed lake approximately 520 m northwest of Shook Lake. Grab samples collected by the field party failed to indicate anything of economic interest.

The trenching is pre-1952 when the property was then examined by Jalore Mining Company Limited. The Judith Iron Range was staked by W. Souliere, A. Biagini and D. Calibani prior to 1951. They granted permission to Jalore Mining Company Limited to examine the property.

JALORE MINING COMPANY LIMITED

Jalore Mining Company Limited examined surface showings completed a dip needle and self potential survey and 3 diamond drill holes in 1952 (AFRO, Toronto). Diamond drilling totalled 343 feet and hole one encountered 5 feet of massive sulphide which returned 0.096% Cu and 0.038% Ni (AFRO, Toronto). The property was determined to be of no interest to the company and work terminated. No additional work has been reported on the Judith Iron Range.

LACCOLITH PROPERTY (52)

In 1926, a large group of claims staked east at Leroy and Lyre Lakes were known as the Laccolith Group (Gledhill 1927, p.43). Rupert (1979, p.145) reported that these claims were cadastrally surveyed at the time of staking, transferred to the Beachurst Realty Corporation in 1928 and cancelled in 1930.

Rupert (1979, p.145, 146) examined pits believed to be on the former Laccolith property and described his findings as follows:

"Pits of substantial dimensions have been cut across two iron formations where they cross the Dill River as shown by Rupert (1975). The central band of iron formation crossing the Dill River shows three separate zones across a width of 60 feet. The southeast side consists of quartz, pyrite, pyrrhotite and traces of arsenopyrite. The central section consists of banded quartz, mariposite and pyrite and the northwest side consists of well banded cherty silica, magnetite, pyrite and pyrrhotite. At a turn in the river a few hundred feet southwest of this pit, felsic and very siliceous tuffs are present well mineralized with 5 to 15% of pyrite. This zone appears to correlate with siliceous sulphide rich zones to the south. The most easterly band of iron formation is roughly 20 feet wide. It consists mainly of interbanded silica, chlorite, magnetite, pyrrhotite and pyrite with traces of chalcopyrite. The structural relationships of the different facies combinations of these minerals were not clearly exposed in any one pit,

although individual pits are over 8 feet deep and up to 20 feet in length. The band of iron formation nearest the Firesand River consists mainly of lean coarsely banded cherty quartz and magnetite.

Extensions of these iron formations to the north and south are based mainly on interpretation of ground magnetic surveys submitted for assessment credit by Pango Gold Mines Limited."

In 1900, several claims were staked east of Lyre Lake and transferred to E.V. Clergue. These claims were located near the pits on the iron formation crossing the Dill River but exact locations are uncertain (Rupert 1979, p.144).

The pitting of the iron formation may have been completed around 1900 by the Laccolith Mining Company. On the basis of Gledhill's (1927, p.43) description, the Laccolith Mining Company examined quartz veins for their gold content and not the iron formation.

There is no record of findings by the Laccolith Mining Company or of the results of work on the thin iron formation units.

LAKE OSU MINES LIMITED (53)

Lake Osu Mines Limited had six unpatented mining claims in McMurray Township in 1963. Five contiguous claims were located east of the former Minto Mine and received most of the work. The sixth claim S S M 61549 was located northwest of the former Minto Mine along the Gold Mine Road.

In June 1963, the company completed electromagnetic and magnetic surveys over the Surluga Gold Mines Limited, Minto, Sunrise and Parkhill properties. The purpose of these surveys was to examine geophysical response to known veins containing gold mineralization. At the Surluga property the magnetic survey identified the Jubilee Shear Zone and a poor conductor coincident with the shear. At the three other sites, the geophysical survey failed to identify gold-bearing veins. At the Surluga property, the structure rather than mineralization was identified by the survey (AFRO, Toronto). Upon completion of these orientation surveys the company completed no additional work on the four properties of Surlago Gold Mines Limited, Minto, Sunrise and Parkhill.

On the 6 claims held by the company, magnetic, electromagnetic and geological surveys were completed. The company completed 3 diamond drill holes on claim S S M 61551 and one hole on claim S S M 61552. This drilling totalled 1217 feet (AFRO, Toronto). Results of the drilling were not available to the author and additional work was not recorded.

Rupert (1979, p.127) indicated that additional unreported work may have been completed in the area by Lake Osu Mines Limited.

LEROY PROPERTY (54)

Approximately 366 m southeast of the shaft of Deep Lake Mines a property known as the LeRoy is reported to consist of 14 veins (MDIR, Toronto). These veins are reported to vary from 3 to 30 feet wide and carry from 0.12 to 4.0 ounces Au per ton (MDIR, Toronto). Three shafts of 40, 45 and 90 feet are reported to have been sunk by the LeRoy Gold Syndicate (MDIR, Toronto). The LeRoy Gold Syndicate is reported to have been succeeded by Gold-Gin Mines Limited in 1939 (MDIR, Toronto). The

author has been unable to locate records of either company. Diorite of the Jubilee Stock was encountered by the field party near an old building on the property. No former workings were found by the field party and E. Frey, District Geologist has made several unsuccessful attempts to locate the shafts.

LLOYDA GOLD MINE (55)

Boyd (1902, p.73; 1903, p.64) reported a shaft on claim M 1276 by United Mining Company Limited, which was referred to as the Lloyd Gold Mine. In 1901 a 7 by 9 foot shaft was at 19 feet and in 1903 the shaft was at 90 feet (Boyd 1902, p.73; 1903, p.64). Information on file at the Mining Records Office in Sault Ste. Marie indicates that the shaft reached a depth of 130 feet and has a crosscut of 30 feet at the bottom.

Claim 309 staked by W. Kimble became claim 837 which was restaked as M 1276 by C. Martin of Titusville, Pennsylvania in 1901. Shaft sinking and development continued from 1901 to 1903. Claim M 1276 was restaked in the 1930's as 3543 and was subsequently restaked by G. Carufel as 3678. Mr. Carufel patented the claim.

There is no record of additional work on the property nor is there any information as to why the shaft was sunk or what was found. Rupert (1979 p.124) did not find the shaft. Rupert (1979, p.124) reported that northeast-trending quartz veins up to 2 feet wide occur at the west outlet of Lloyd Lake. He reported one vein to consist of mainly quartz and carbonate and to be weakly radioactive. A trench north of the outlet of Lloyd Lake exposed agglomeratic dacite with over 5% pyrite (Rupert 1979, p.124).

MACKEY POINT MINES LIMITED (42E)

(SEE CITADEL GOLD MINES INCORPORATED)

MARIPOSA GOLD MINING COMPANY (47B)

(SEE DUNRAINE MINES LIMITED)

McMARMAC RED LAKE GOLD MINES LIMITED (56)

McMarmac Red Lake Gold Mines Limited completed two diamond drill holes and one abandoned hole on claim S S M 64498 and one diamond drill hole on claim S S M 64499 in 1964. This drilling totalled 3214 feet including water and overburden to bedrock (AFRO, Toronto). Information concerning the results of this drilling is generally unavailable. Assay data accompanying the log from the bottom of hole M-1 gave a maximum value of 0.005 ounces Au per ton.

MICHIPICOTEN GOLD MINES LIMITED (57A)

(SEE VAN SICKLE MINE)

Michipicoten Gold Mines Limited was incorporated in 1934 and held a group of claims adjacent to the Parkhill, Minto and Van Sickle properties (Canadian Mines Handbook 1937, p.170). This group of claims covered several gold-bearing veins. The Van Sickle Vein was in 1936 under option to the company. Work on the Van Sickle and Sunrise veins is discussed under their respective headings. Other veins on the former property have been examined and described by Hesse (1937). Since time did not permit

location and examination of these veins the observations of Hesse will be summarized below.

Rupert (1979, p.133) reported that the veins are present in porphyritic metavolcanic rocks (Jubilee Tuffs) and that pink alteration zones are common. He described the veins as follows:

"The veins consist of slightly smoky grey quartz to fine-grained varieties with a sugary texture. Up to 5% tourmaline is present in some specimens and scattered vugs in the vein carry coarse-grained pyrite and minor pyrrhotite. All of these veins smell strongly of arsenic when freshly broken."

The charter for Michipicoten Gold Mines Limited was cancelled in 1952 (Canadian Mines Register, Dormant and Defunct Mines p.250).

BIG CARBONATE VEIN

This vein is found at the northeast corner of Deep Lake and is indicated on a sketch map of the Van Sickle property. Rupert (1975 1979, p.101) indicated trenching and radioactivity due to thorium on this vein. There is no indication of gold in this vein. On the southwest shore of Deep Lake a zone of intense carbonate alteration was encountered by the writer which may be the southwestern extension of this vein.

CAPTAIN VEIN

Approximately 60 m north of the Van Sickle Vein on which the shaft was sunk lies the Captain Vein (Hesse 1937, p.7). This vein strikes 290° and dips 45 to 60°N (Hesse 1937, p.7). Hesse (1937) reported this vein consists of several parallel stringers up to 8 feet wide and has been traced for 500 feet. The vein occupies a shear zone up to 15 feet wide which is mineralized with fine-grain disseminated pyrite. The presence of gold was not indicated.

CREEK VEIN

On the narrow ridge between Trout Creek and Van Creek (local name), Hesse (1937, p.7) reported the presence of a shear zone with quartz stringers and lenses up to 3 feet wide. The exact strike and dip could not be determined but the vein lies on strike with the Parkhill Vein. The presence of gold was not recorded. This vein was traced to within 150 feet of the eastern extension of the Parkhill Vein.

GREAT NORTHERN VEIN

The sketch map of the Van Sickle property indicates a vein known as the Great Northern situated approximately 900 feet north of the northwest corner of Deep Lake. The sketch map suggests two closely spaced veins trending approximately 320°. There is no information concerning this vein but the sketch map suggests that visible gold may have been recognized (AFRO, Toronto).

LUCKY STRIKE VEIN

The Lucky Strike Vein strikes 130° and dips approximately 60° northeast (Hesse 1937, p.5). Hesse (1937) reported the width to be approximately 3 feet with a length of 350 feet. The best section returned \$3.00 Au over 36 inches for a length of 90 feet (Hesse 1937, p.5). The gold content appears insignificant. Rupert (1979, p.133) reported that the Lucky Strike Vein strikes at 120°, dips north at about 50° and is 18 inches wide near the Beaver Pond on Trout Creek.

MICKELSON VEIN (57B)

The Mickelson Vein occurs approximately 200 feet south of the Sunrise Vein (Hesse 1937, p.4). Hesse (1937, p.5) reported on sampling completed by a Mr. S.L. Bright as follows:

"Sampling of the so-called Mickelson vein, two hundred feet south of the Sunrise vein gave the following results:

\$1.05	over	50",	\$ 0.70	over	72",	\$ 2.10	over	54"
40.60	"	38",	0.70	"	42",	8.05	"	41"
2.80	"	14",	97.30	"	26",	112.70	"	16"
63.70	"	12",	176.20	"	11",	2.80	"	14"

Channel and in some cases bulk samples were taken every five feet going east from the west end of the vein near No.1 corner post of claim #4141.

In 1935, Mr. S.L. Bright, Mining Engineer from Detroit took bulk samples from the same vein on five different places.

The results were as follows:

#1. - \$127.75; #2. - \$105.35; #3. - \$2.80; #4. - \$27.65; #5. - \$116.20.

A bulk sample of four tons taken from this vein over a length of about 60 feet was crushed and sampled at Parkhill Gold Mines and gave an average of \$22.45 (0.64 ounces Au per ton)."

Sampling by Hesse (1937) indicated the presence of erratic gold values in the Mickelson Vein. The values given by (Hesse 1937) are assumed to be at \$35.00 per ounce.

WILCOX VEIN

The Wilcox Vein occurs 300 feet south of the Sunrise Vein or 100 feet south of the Mickelson Vein (Rupert 1979, p.133). The vein is reported to have a strike of 95° and a dip of approximately 40°N (Rupert 1979, p.133). The vein is traceable for 220 feet has a width of 8 inches and at its east end has a pit 12 feet deep (Rupert 1979, p.133). Gold values have not been reported from this vein.

MILMAC MINES LIMITED

Milmac Mines Limited held a large block of ground south of the Darwin Mine extending into Rabazo Township to the south. This company completed work on gold showings within its claim block. These showings lie within Rabazo Township and the reader should refer to Massey (1925) for details.

MINTO GOLD MINES LIMITED (42F)
(SEE CITADEL GOLD MINES INCORPORATED)
MORRISON PROPERTY (58)

Mr. R. Morrison completed three short diamond drill holes on claim S S M 48245 in 1956 (AFRO, Toronto). This drilling totalled 201.5 feet. The results of this drilling are unknown. The drilling may have been done to find the southeastern extension of the quartz vein on the Anderson property.

NORTHERN HORIZON RESOURCES LIMITED (59)

Northern Horizon Resources Limited held a 10 claim block along the south boundary of McMurray Township west and south of Reed Lake. In 1981, a magnetometer survey was completed over the property. No other work has been reported.

NYMAN, W. (60)

In 1975, Mr. W. Nyman held three claims numbers S S M 321878 thru 321880 south of the Citadel Gold Mines Incorporated property. A VLF electromagnetic survey was completed over the property. There is no record of additional work.

PANGO GOLD MINES LIMITED (42)
(SEE CITADEL GOLD MINES INCORPORATED)
(PARKHILL GOLD MINES LIMITED (47C))
(SEE DUNRAINE MINES LIMITED)
PETERSON GROUP

Reference to a group of claims known as the Peterson Group is made in Assessment work records. The report (approximately 1923) indicates a shaft 130 feet deep and 1000 ton stock pile of ore on the property. The location given is 3 miles from Wawa. The location of this property is unknown but most activity and development at this time was along or close to the Jubilee, Minto and Parkhill properties. The report may refer to the Lloyd Gold Mines property which has a shaft reported to be 130 feet deep.

PURSIDES GOLD MINES LIMITED (42)
(SEE CITADEL GOLD MINES INCORPORATED)
SHIER GROUP

This is a 5 claim group located approximately 0.8 km east of Jubilee Lake (Gledhill 1927, p.48). Quartz veins are reported to be present on this property but no work has been reported.

SOO MINING COMPANY

The Soo Mining Company owned claim S S M 3491 on which sugary quartz veining containing minor galena and sphalerite is reported (Gledhill 1927, p.46). The galena and sphalerite bearing vein has been pitted and a parallel vein north of the one pitted is reported to contain pyrrhotite (Gledhill 1927, p.46). The precise location of the showing is uncertain but it may be on strike with quartz veins described under the Mariposa prospect.

S.B. SMITH MINE (63)
(SEE VAN SICKLE MINE)
STANLEY GOLD MINE (61)

The Smith vein on which the Stanley Mine was developed occurs 700 feet north of the east end of Stanley Lake. Rupert (1979, p.76) described the vein system at the Stanley Mine as follows:

"Three connecting vein structures are present here: The Smith vein and the parallel Compressor vein to the southwest, dip 40|NE and strike 130|; the Mickelson vein is a short connecting vein 60 to 70 feet long between the other two, with a dip about 30|S and strike nearly north and south. The Smith vein was traced for a total length of 640 feet underground and the Compressor vein was traced for an additional 700 feet northwest on surface. These veins have a left hand en echelon arrangement. Width varies from 12 feet in a section on the second level to only a few inches of sheared rock in other parts. Lenses of wide ore sections plunged east with an azimuth of 075|, parallel to the intersection of the Mickelson vein and the Smith vein. The Smith vein steepens north of and below the intersection. One "ore" shoot about 90 feet long (horizontally) was at this intersection and the other was about 200 feet to the south of it on the Smith vein, with a horizontal length of about 130 feet. Both were stoped on the first level only."

The strike and dips cited by Frohberg (1935, p.76, 77) are similar to those measured by Rupert. Frohberg (1935, 76, 77) mentioned that the Compressor Vein occurs 60 feet west of the Smith Vein and that the Mickelson Vein occurs 100 feet north of the Stanley Mine shaft.

Frohberg (1935, p.77) described the quartz of the Smith Vein as sugary with minor pyrite, pyrrhotite, chalcopyrite and sphalerite. Little gold was recognized by Frohberg but he mentioned that rich vein material occurred at the junction of the Mickleson and Smith Veins (Frohberg 1935, p.77).

A vein known as the O'Keefe is located approximately 700 feet northeast of the Smith Vein. This vein was not examined by the author or by Rupert (1979). Gledhill (1927, p.47) indicated the position of the vein on his map and described the vein as follows:

"O'Keefe Vein (Claim No.4,641)

Near the south shore of Wawa Lake a narrow northwest-southeast vein was found close to the Smith Vein. The country is very hilly in this vicinity and the vein appears on the face of a steep ridge that faces

north and borders the south shore of Wawa Lake. The maximum width of the O'Keefe gold-quartz vein was about six inches. The quartz is crushed and shows pyrite and chalcopyrite and some fairly coarse gold."

In proximity to the Stanley Mine, the field party examined granodiorite to diorite rocks of the Jubilee Stock and fragmental intermediate to felsic metavolcanic rocks. Rupert (1975) mapped the clastic rocks as metasedimentary rocks.

Rupert (1979, p.76, 77) conducted more detailed examination of the rocks at the mine sites. He described them as follows:

"Wall rocks observed by the writer in this area were all greywackes, arenaceous conglomerate, although the mine plan identifies them as Keewatin Greenstone and basic schists. The bedding attitudes determined in the wall rocks by the writer within 1/4 mile are all nearly parallel to the Smith vein. The wider parts of the vein were solid quartz lenses, but widths of up to 4 feet of sheared rock with quartz stringers have been mapped near the ends of the lenses. Elsewhere the vein is a shear zone less than 2 or 3 feet wide."

The Smith Vein was discovered prior to Gledhill's (1927) examination but information as to exactly when and by whom appears to be lost.

Stanley Gold Mines Limited was incorporated in November 1933 to take over a property acquired by Stanley Siscoe Extension Gold Mines Limited which started shaft sinking on September 1, 1933 (Sinclair 1934, p.98). The original shaft was sunk by hand at an angle of 33° to a depth of 30 feet and operations ceased until equipment and power arrived (Sinclair 1935, p.141). Shaft sinking resumed in February 1934 and by the end of 1936 the shaft was at a depth of 392 feet with levels at 123 feet and 256 feet (Sinclair 1935, p.141; 1936, p.204). At the first level the angle of the shaft was increased from 33° to 47° (Sinclair 1935, p.141). A third level was established at 360 feet and open stoping on the first level began in July 1936 (Sinclair 1937, p.204). A 50 ton per-day amalgamation mill was placed in production in July 1936 and 1,963 tons milled producing 84 ounces of Au (Sinclair 1937, p.204; MDIR, Toronto).

The shaft was sunk an additional 158 feet to a depth of 550 feet in 1937 and the company was declared bankrupt in December 1937 (Sinclair 1938, p.208). Froberg (1935, p.76) placed the three levels at 138, 275 and 380 feet. These depths are at variance with other sources of information (MDIR, Toronto). Approximately 1,919 feet of lateral work has been completed (MDIR, Toronto).

MARBOY MINES LIMITED

In 1964, Marboy Mines Limited completed 3 diamond drill holes on claim S S M 62953 close to the Stanley Mine Shaft. This drilling totalled 1006 feet (AFRO, Toronto). Assays reported vary from nil to 0.005 ounces Au per ton (AFRO).

In 1970, Pango Gold Mines Limited conducted a magnetometer survey over the property.

Mr. C. C. Clement is reported to have owned the property in 1973 and to have completed some trenching (MDIR, Toronto).

The mine has not been examined since it closed and based on its recorded production, gold mineralization is very low grade. Based on production figures, the ore averaged 0.043 ounces Au per ton.

SUNRISE PROSPECT (62)

The Sunrise prospect is located approximately 914 m northeast of the Parkhill Shaft. This prospect was investigated very early in the history of the area.

Gledhill (1927, p.46) described the vein as white to grey glassy quartz with minor sulphide. The wall rock was described by him as diorite displaying a biotitic alteration (Gledhill 1927, p.46).

Rupert (1979, p.133) visited the property and described the vein as follows:

"The Sunrise shaft is about 700 feet west of the Lucky Strike vein. It is reported (Boyd 1904) to be 100 feet deep, although the adjacent spoil piles do not account for so much rock. The shaft is on a 24 inch quartz vein exposed for nearly 200 feet to the west in trenches. It strikes about 080°

and the dip, indicated by the inclination of the shaft, is 60°W. A second vein about 50 feet south of the shaft is 8 inches wide, strikes about 115°E and dips 25° north. These two veins intersect about 150 feet west of the shaft. The plan mentioned above shows these veins to have length of 210 and 140 feet respectively."

Rupert (1979, p.133) reported that the veins occur in intermediate to felsic metavolcanic rocks with dikes of diorite from the Jubilee Stock. He described the veins in the area as fine-grained, smoky grey, sugary quartz with coarse-grained pyrite and pyrrhotite (Rupert 1979, p.137). Gledhill (1927, p.46) reported chalcopyrite to be dominant but this was not confirmed by Rupert (1979). Tourmaline in quantities up to 5% is present in some samples of the vein and all vein material had a odor of arsenic immediately upon being broken (Rupert 1979, p.134).

The Sunrise Vein has been controlled or examined by A. B. Blackinton, C. A. Sheir, L. A. Van Sickle, Sunrise Mining Company, Michipicoten Gold Mines Limited, Mr. W. Hesse, Lake Ose Mines Limited, the Wawa Syndicate, the Seneca Gold, Copper and Nickel Company Limited and several others (Rupert 1979, p.132). Records of work completed by most of these various individuals and groups could not be located.

In 1902 to 1903, the Sunrise Mining Company Limited sank one 100 foot inclined shaft at approximately 60° and a vertical shaft with a minimum depth of 20 feet (Boyd 1903, p.63, 1904, p.47).

PARKHILL GOLD MINES LIMITED

In 1933, the vein was sampled by Parkhill Gold Mines Limited. The sampling by Parkhill Gold Mines Limited was reported by Hesse (1937, p.4), and is given as follows:

"The vein on the south part of claim S S M 3047 is called the Sunrise vein. On this vein a 6' by 9' shaft has been sunk in the old days. This shaft is supposed to have a depth of 100 feet, but has never been dewatered. This vein was channel sampled by Parkhill Gold Mines in 1933 for a length of 100 feet. The results were as follows:

(Values given at Au price of \$35.00 per oz.)

12" - \$ 1.40;	9" - \$ 2.80;	7" - \$ 7.00;	16" - \$ 1.40
16" - 1.40;	16" - 1.40;	12" - 2.80;	16" - 1.40
16" - 1.80;	13" 3.50;	14" - 46.20;	14" - 24.50
12" - 1.40;	14" 2.10;	24" - 8.75;	26" - 3.50
28" - 2.80;	24" 3.50;	21" - 3.50;	24" - 4.20
18" - 1.75;	21" 3.15;	14" - 14.00;	12" - 2.80
17" - 2.80;	12" 4.55;	18" - 2.80	

Another vein which runs off the Sunrise vein, about 30 feet south of the shaft, was channel sampled for a length of 65 feet with the following results:

8" - \$5.65;	10" - \$ 9.45;	18" - \$32.37;	18" - \$14.00;
20" - 7.00;	20" - 38.50;	24" - 2.80;	17" - 3.50;
10" - 2.80;	24" - 9.45;	10" - 15.75;	17" - 7.15;
28" - 25.55			

Parkhill Gold Mines also had two bulk samples taken from this same vein which gave the following results: \$15.75 for a width of 24" and \$38.99 for a width of 32". In 1935, S.L. Bright, Mining Engineer from Detroit, took bulk samples from the same vein on five different places. The results were as follows:

#1. - \$31.85; #2. - \$191.80; #3. - \$ 18.20; #4. - \$110.25;
#6. - 8.75."

The sampling by Parkhill Gold Mines Limited indicates erratic but generally low gold values in the Sunrise Vein.

From 1934 to 1952, the Sunrise Vein was part of the holdings of Michipicoten Gold Mines Limited. The company is reported to have completed geological mapping, trenching, stripping, sampling and diamond drilling, however, records for this work could not be located (MDIR, Toronto).

In 1961, H. Lang had an option on the property but there is no record of work by him.

L. A. Van Sickle is reported to have completed stripping trenching and sampling in 1966 and 1967 (MDIR, Toronto). There is no record of additional work on the property.

TREMBLY CLAIMS

Three claims numbered S S M 863 through 865 located in the northwest corner of McMurray Township have reported gold assays (MDIR, Toronto). Trenching is reported as being completed however the precise location of this work is unknown (MDIR, Toronto).

VAN SICKLE MINE (62) (FORMERLY S. B. SMITH MINE) (FORMERLY MICHIPICOTEN GOLD MINES LIMITED)

The Van Sickle Mine lies east of and adjacent to the Parkhill Mine. The Van Sickle Vein also known as the Smith vein appears to occupy the same stratigraphic position as the Parkhill Vein, however, possible faulting between the two properties makes correlation speculative (Frohberg 1935, p.80). Rupert (1979, p.104) considered the Van Sickle Vein to be the same as the Parkhill. The geology of the Van Sickle vein (Smith Vein) is described by Frohberg (1935, p.80) as follows:

"Striking approximately N. 60° E., the Smith vein dips southward at an angle of 45° from the surface to a point about 20 feet above the 1st level and then steepens to over 55°. In the shaft and the drifts the vein is seen to consist of a

series of quartz lenses, which range in width from a few inches to almost 4 feet. The length of the ore zone as established on the stripped surface is over 200 feet, although the vein has been traced as a barren shear zone for a considerably greater distance. As indicated by the stopes between the 1st level and the surface, the quartz bodies have a moderate rake to the west. A limited amount of drifting was carried out on the 2nd level but apparently failed to locate the downward extension of the vein. Since the horizontal distance from the mouth of the shaft to the south boundary of claim S.S.M.301 is about 800 feet, it is to be expected that the Smith vein will enter claim S.S.M.1,107 of Parkhill Gold Mines at a vertical depth of about 900 feet. If the strike of the Smith vein is projected toward the west, it appears to be in line with the surface outcrop of Parkhill vein No.2, 300 feet west of the shaft. The Smith vein, however, is faulted by a wide diabase dike and this fact, as well as other intervening lines of disturbance, makes it impossible at present to correlate definitely the Smith vein with any of the easterly veins of the Parkhill mine."

The vein quartz is sugary and carries pyrrhotite, chalcopyrite and fine native gold (Frohberg 1935, p.80). Some calcite and small amounts of tourmaline are present as gangue minerals (Frohberg 1935, p.80). Rupert (1979, p.104) found arsenopyrite on the waste dump of the mine.

The Van Sickle Vein is reported by Rupert (1979, p.103) to be transverse to a 500 foot tongue of diorite to granodiorite intrusive rock of the Jubilee Stock. The intrusion contains abundant xenoliths of metavolcanic material and Rupert (1979, p.103) suggested that 75% of mine workings were in such mixed rocks, the remainder being in metavolcanic rocks. On surface, the vein extends west into intermediate to felsic lapilli crystal tuffs and agglomerates (Rupert 1979, p.103). The vein has been followed for several hundred feet on the second level of the mine. The productive part of the vein appears restricted within or very close to the dioritic intrusions (Rupert 1979, p.103).

Rupert (1979, p.104) reported that if the dioritic host persists to depth then exploration between the Van Sickle and Parkhill Mines is warranted. He also reported that a shear zone that correlates with the Van Sickle Vein is present 0.8 km east of the mine near the outlet of Deep Lake and that as this shear cuts dioritic rocks it may be worth exploring (Rupert 1975, p.105).

Recorded production from the Van Sickle Vein is 1,536 ounces Au and 75 ounces of Ag from 9,288 tons of ore (MDIR, Toronto). The Globe and Mail (August 21, 1936) indicated reserves of 10,000 tons at \$16.00 (Au at \$35.00 per ounce) and the Northern Miner (August 12, 1937) gives reserves of 1,000 tons at \$20.00 per ounce.

The original claim on which the mine is located was staked in 1898 by W.B. Van Sickle (Rupert 1979, p.102). There are no records concerning early prospecting on this claim. In 1926, C. Michael of the Wawa Syndicate optioned the property who assigned the option to the Huronian Belt Company Limited, then to the Pioneer Mining Corporation Limited and then for a short time in 1931, to Parkhill Gold Mines Limited (Rupert 1979, p.102; MDIR, Toronto). There is no record of work on the property by these companies. Apparently the property reverted back to L. A. Van Sickle who in September 1933 discovered the vein from which production was obtained (Rupert 1979, p.102).

S.B. SMITH

The property was optioned in the year of discovery to S. B. Smith of Cleveland, Ohio. Shaft sinking began in May of 1934 (Sinclair 1935, p.140). The shaft was sunk at a 45° angle to an ultimate depth of 289 feet with levels at 119 feet and 261 feet (Sinclair 1935, p.140, 1936, p.158). A 50 ton per day amalgamation mill was erected in 1935 and production was obtained from May 1935 until February 1936 (Frohberg 1935, p.80).

MICHIPICOTEN GOLD MINES LIMITED

After operations were suspended in February 1936 a short period of time lapsed before the mine was optioned to Michipicoten Gold Mines Limited. This company was incorporated in March 1934 and held a group of claims lying north and adjacent to the Van Sickle property at the time of the option (Canadian Mines Handbook 1937, p.170).

There is no record of Michipicoten Gold Mines Limited having completed work on the property. The charter for the company was cancelled in 1952 (Canadian Mines Register of Dormant and Defunct Mines, p.251).

H. L. Lang optioned the property in 1961 and completed a geologic map on the property but no additional work was reported.

DUNRAINE MINES LIMITED

In October 1980, the property was optioned by Dunraine Mines Limited and several diamond drill holes completed between the Parkhill and Van Sickle Mines. The holes failed to intersect significant mineralization. The Dunraine Mines Limited option was dropped on November 1, 1982 (H. Koza, Dunraine Mines Ltd., personal communication).

WAWA GOLDFIELDS (42G)
(SEE CITADEL GOLD MINES INCORPORATED)
WAR EAGLE (64)
(VILLENEUVE PROPERTY)

This showing was briefly visited by the field party. The old pitting and trenching was covered. Gledhill (1927, p.49) described the geology of the War Eagle occurrence as follows:

"At the north end of the workings a well-mineralized, vertical, quartz fissure vein about three feet wide cuts through a hill composed of greenstone and quartz porphyry. At the base of the hill a pit has been sunk on the vein. A little south of the pit, Keewatin schist filled with small, branching quartz veins has been contorted and drag-folded in a northeast direction.

At the southern part of the trenching, a hillside has been stripped to bed rock and there has been exposed on it a large quartz vein that strikes north. The Keewatin schist that forms the principal rock in this place is filled with small quartz veinlets that have been drag-folded and granulated; in places the chlorite schist has been altered to biotite. Where the sulphides are most abundant, needles of arsenopyrite and tourmaline and crystals of pyrite are found in a sericite schist. This ore assayed \$9.20 per ton in gold.

The gold mineralization on this claim is in a roof pendant of basic Keewatin schist. The schistose gold-bearing rock appears to extend northeast and southwest, while the pronounced fissure quartz veins trend north and cut the schist belt. Mineralization and quartz veins were noted east and west of the work on claim No.3,492."

The name of the original discoverer has been lost and the trenching, pitting and sampling described by Gledhill (1927) was completed before he examined the showing. When and by whom this work was completed is unknown.

In 1962, when it was known as the Villeneuve prospect 6 diamond drill holes were completed under the direction of Mr. D. Sutherland. This drilling totalled 1129 feet (AFRO, Toronto). The precise location of this drilling is uncertain. Significant mineralization was not encountered. Trace quantities of copper were present in hole 3. The rocks reported in drilling are diorite, feldspar crystal tuff, quartz-carbonate cemented breccia and lamprophyre.

There is no record of additional work on the property.

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	Multiplied by	Gives	Imperial Unit	Multiplied by	Gives
LENGTH					
1 mm	0.039 37	inches	1 inch	25.4	mm
1 cm	0.393 70	inches	1 inch	2.54	cm
1 m	3.280 84	feet	1 foot	0.304 8	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	1.609 344	km
AREA					
1 cm ²	0.155 0	square inches	1 square inch	6.451 6	cm ²
1 m ²	10.763 9	square feet	1 square foot	0.092 903 04	m ²
1 km ²	0.386 10	square miles	1 square mile	2.589 988	km ²
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
VOLUME					
1 cm ³	0.061 02	cubic inches	1 cubic inch	16.387 064	cm ³
1 m ³	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m ³
1 m ³	1.308 0	cubic yards	1 cubic yard	0.764 555	m ³
CAPACITY					
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	4.546 090	L
MASS					
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	31.103 476 8	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	0.453 592 37	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	907.184 74	kg
1 t	1.102 311	tons (short)	1 ton (short)	0.907 184 74	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	1016.046 908 8	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	1.016 046 908 8	t
CONCENTRATION					
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.

SAGE
QUARTZ FELDSPAR PORPHYRIES, AREA I

MAJOR OXIDE LISTING

	79RPS-6478	79RPS-6479	79RPS-0017	79RPS-0077	79RPS-0078	79RPS-0079
SiO2	74.10	69.50	69.00	73.60	76.90	74.60
Al2O3	14.30	14.40	16.30	13.80	13.10	13.20
Fe2O3	0.90	1.15	0.43	0.38	0.49	0.92
FeO	0.83	1.08	0.57	1.38	0.57	1.30
MgO	0.58	0.84	0.49	0.76	0.34	0.39
CaO	0.79	2.96	2.78	1.34	2.07	2.01
Na2O	2.88	2.53	4.74	5.84	3.99	3.63
K2O	3.20	3.53	1.57	0.10	0.90	1.88
TiO2	0.26	0.52	0.27	0.26	0.49	0.38
P2O5	0.03	0.11	00.00	00.00	00.00	00.00
MnO	0.02	0.04	0.02	0.03	0.01	0.03
CO2	0.62	2.33	2.27	0.12	0.24	0.11
S	0.01	0.06	0.01	0.01	0.01	0.01
H2O+	0.89	0.93	0.61	0.61	0.46	0.21
H2O-	0.09	0.12	0.05	0.09	0.11	0.07
LOI	1.90	3.40	3.20	0.70	0.80	0.70
TOTAL	99.50	100.10	99.10	98.30	99.70	98.70
S.G.	2.71	2.73	2.69	2.67	2.69	2.71

TRACE ELEMENT LISTING

METHOD	79RPS-6478	79RPS-6479	79RPS-0017	79RPS-0077	79RPS-0078	79RPS-0079
Ag AA	-2	-2	-2	-2	-2	-2
As AA	-1 M	1.5M	3 M	-1 M	-1 M	2 M
Au AA	6 B	3 B	-2 B	-2 B	-2 B	15 B
Ba AA	1200	1200	770	70	440	750
Co AA	-5	11	-5	6	-5	5
Cr AA	-5	-5	7	5	-5	5
Cu AA	10	50	6	5	18	12
Li AA	5	8	9	4	6	6
Ni AA	-5	-5	-5	5	-5	-5
Pb AA	-10	62	-10	-10	-10	19
Sb AA	-0.1M	-0.1M	1 M	0.2M	0.1M	2.8M
Zn AA	20	26	26	26	20	39
Mo ICP/OES	-5	-5	-10	-10	-10	-10
Sr ICP/OES	25	60	320	35	95	85
V ICP/OES	23	50	15	19	16	22
Y ICP/OES	13	19	-1	4	11	8
Ga XRF	15	18	13	7	11	10
Rb XRF	70	80	30	8	20	29
Zr XRF	110	140	40	140	140	165
Ce ICP-MS	155	120	-35	110	75	160
La ICP-MS	80	60	-30	40	-30	115
Nd ICP-MS	38	36	-20	30	25	55

MAJOR OXIDE LISTING

	79RPS-0092	79RPS-0093	79RPS-0094	79RPS-0095	79RPS-0097	79RPS-0098
SiO2	75.50	75.40	75.60	74.40	75.90	75.30
Al2O3	13.10	13.60	13.80	14.20	13.40	13.20
Fe2O3	0.12	0.36	0.90	0.80	0.43	0.59
FeO	0.41	0.89	0.41	0.32	0.49	1.38
MgO	0.82	1.18	0.27	0.31	1.04	0.98
CaO	1.48	0.70	3.53	3.85	1.64	0.42
Na2O	4.57	4.23	4.05	3.41	3.59	4.10
K2O	1.65	1.69	0.49	0.57	1.70	1.42
TiO2	0.25	0.31	0.37	0.26	0.21	0.23
P2O5	00.00	00.00	00.00	00.00	00.00	00.00
MnO	0.02	0.03	0.03	0.02	0.18	0.03
CO2	0.78	0.11	0.09	0.10	0.30	0.09
S	00.00	00.00	0.01	0.01	0.01	0.01
H2O+	0.37	0.54	0.06	0.17	0.45	0.73
H2O-	0.11	0.13	0.12	0.13	0.17	0.11
LOI	1.50	1.00	0.90	0.70	1.10	1.10
TOTAL	99.20	99.20	99.70	98.60	99.50	98.60
S.G.	2.68	2.69	2.72	2.72	2.69	2.68

TRACE ELEMENT LISTING

METHOD	79RPS-0092	79RPS-0093	79RPS-0094	79RPS-0095	79RPS-0097	79RPS-0098
Ag AA	-2	-2	-2	-2	-2	-2
As AA	-1 M	-1 M	1 M	-1 M	-1 M	-1 M
Au AA	-2 B	-2 B	-2 B	-2 B	-2 B	-2 B
Ba AA	780	620	330	160	1080	590
Co AA	-5	5	-5	-5	-5	6
Cr AA	-5	-5	-5	-5	-5	-5
Cu AA	-5	18	-5	-5	-5	-5
Li AA	6	8	-3	-3	6	6
Ni AA	-5	-5	-5	-5	-5	-5
Pb AA	-10	-10	-10	-10	-10	-10
Sb AA	0.1M	0.7M	0.3M	0.3M	0.1M	0.1M
Zn AA	18	25	18	16	18	33
Mo ICP/OES	-10	-10	-10	-10	-10	-10
Sr ICP/OES	65	40	185	210	55	12
V ICP/OES	15	15	18	14	15	14
Y ICP/OES	12	11	13	16	8	6
Ga XRF	10	10	13	12	13	10
Rb XRF	31	36	18	24	34	21
Zr XRF	110	135	150	115	105	120
Ce ICP-MS	140	155	75	120	115	100
La ICP-MS	45	80	-30	35	40	-30
Nd ICP-MS	40	40	25	35	30	20

MAJOR OXIDE LISTING

	79RPS-0105	79RPS-0107	79RPS-6510	79RPS-6511	83RPS-0162
SiO ₂	76.30	75.10	68.60	67.70	75.90
Al ₂ O ₃	13.30	13.30	16.30	14.40	12.10
Fe ₂ O ₃	0.73	0.50	1.00	1.17	0.82
FeO	0.73	1.05	1.91	2.08	1.53
MgO	0.41	0.72	1.21	1.08	1.39
CaO	0.22	0.38	1.36	2.64	0.72
Na ₂ O	2.89	3.86	3.64	4.37	3.17
K ₂ O	2.64	2.42	2.16	2.29	1.84
TiO ₂	0.21	0.23	0.33	0.33	0.26
P ₂ O ₅	00.00	00.00	0.04	0.05	0.01
MnO	0.03	0.02	0.04	0.05	0.03
CO ₂	0.18	0.16	0.94	1.97	0.16
S	0.02	0.02	0.04	0.01	0.18
H ₂ O+	0.44	0.50	1.81	1.10	1.47
H ₂ O-	0.08	0.09	0.15	0.15	0.06
LOI	1.50	1.10	2.70	2.80	1.20
TOTAL	98.20	98.40	99.50	99.40	99.60
S.G.	2.69	2.68	2.70	2.71	2.69

TRACE ELEMENT LISTING

METHOD	79RPS-0105	79RPS-0107	79RPS-6510	79RPS-6511	83RPS-0162
Ag AA	-2	-2	-2	-2	-2
As AA	1 M	-1 M	-1 M	-1 M	-1 M
Au AA	-2 B	-2 B	-2 B	-2 B	7 B
Ba AA	630	970	620	580	630
Co AA	-5	-5	7	6	8
Cr AA	-5	13	12	8	63
Cu AA	10	12	18	6	42
Li AA	8	7	6	8	6
Ni AA	-5	-5	9	6	20
Pb AA	-10	-10	-10	-10	85
Sb AA	0.2M	0.9M	0.2M	0.2M	0.8M
Zn AA	36	32	37	54	34
Be ICP/OES					-1
Mo ICP/OES	-10	-10	-5	-5	-10
Sc ICP/OES					2
Sr ICP/OES	10	10	135	175	40
V ICP/OES	12	15	55	40	19
Y ICP/OES	6	7	14	20	25
Ga XRF	11	8	12	14	14
Nb XRF					5
Rb XRF	53	45	49	65	40
Zr XRF	115	120	135	135	100
Sm ICP-MS					-15
Eu ICP-MS					-1 M
Gd ICP-MS					-5
Dy ICP-MS					8 M

Yb	ICP-MS					-1	M
Ce	ICP-MS	105	155	75	90	85	
La	ICP-MS	55	40	40	-30	45	
Nd	ICP-MS	35	45	32	30	-30	

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

17

	MEAN	STD. DEVIATION
SiO2	73.73	3.00
Al2O3	13.87	1.08
Fe2O3	0.69	0.30
FeO	1.00	0.53
MgO	0.75	0.35
CaO	1.70	1.13
Na2O	3.85	0.80
K2O	1.77	0.92
TiO2	0.30	0.09
P2O5	0.01	0.03
MnO	0.04	0.04
CO2	0.62	0.79
S	0.02	0.04
H2O+	0.67	0.46
H2O-	0.11	0.03
LOI	1.55	0.91
TOTAL	99.14	0.57
S.G.	2.70	0.02

TRACE ELEMENT STATISTICS

NO. OF SAMPLES		MEAN	STD. DEVIATION
Ag	17	-2.00	0.00
As	17	-0.21	1.34
Au	17	0.29	4.81
Ba	17	671.76	322.07
Co	17	0.53	6.19
Cr	17	3.71	16.70
Cu	17	10.71	15.81
Li	17	5.47	3.43
Ni	17	-1.47	7.20
Pb	17	1.53	28.27
Sb	17	0.46	0.69
Zn	17	28.12	10.04
Be	1	-1.00	0.00
Mo	17	-8.82	2.19
Sc	1	2.00	0.00
Sr	17	91.59	86.41
V	17	22.18	13.09
Y	17	11.29	6.42
Ga	17	11.82	2.67
Nb	1	5.00	0.00
Rb	17	38.41	19.74
Zr	17	122.06	27.39
Sm	1	-15.00	0.00
Eu	1	-1.00	0.00
Gd	1	-5.00	0.00
Dy	1	8.00	0.00
Yb	1	-1.00	0.00
Ce	17	105.88	46.95
La	17	30.88	45.15
Nd	17	27.41	21.42

SAGE
MAFIC INTRUSIVE FOOTWALL, AREA I

MAJOR OXIDE LISTING

	79RPS-0001	79RPS-0002	79RPS-0003	79RPS-0004	79RPS-0005	79RPS-0006
SiO ₂	46.90	46.90	44.10	45.40	49.40	47.60
Al ₂ O ₃	14.40	14.10	12.40	14.10	14.70	17.00
Fe ₂ O ₃	2.65	3.31	2.80	3.40	5.08	4.48
FeO	6.80	6.56	9.23	9.07	8.75	6.32
MgO	11.80	11.10	6.27	7.10	4.90	5.40
CaO	11.80	12.70	9.45	6.64	9.61	12.10
Na ₂ O	0.86	0.77	1.61	2.19	1.74	2.04
K ₂ O	00.00	0.05	00.00	0.08	00.00	00.00
TiO ₂	0.31	0.36	0.90	0.86	0.95	0.93
P ₂ O ₅	00.00	00.00	0.01	00.00	00.00	0.01
MnO	0.15	0.17	0.17	0.14	0.18	0.15
CO ₂	0.22	0.24	7.05	5.70	0.40	0.20
S	0.05	0.07	0.09	0.07	0.06	0.08
H ₂ O+	2.87	2.16	4.60	4.64	2.60	2.16
H ₂ O-	0.13	0.19	0.16	0.46	0.17	0.14
LOI	3.40	2.90	10.40	9.70	2.90	2.50
TOTAL	98.90	98.70	98.80	99.90	98.50	98.60
S.G.	3.03	3.05	2.81	2.79	3.00	3.05

TRACE ELEMENT LISTING

METHOD	79RPS-0001	79RPS-0002	79RPS-0003	79RPS-0004	79RPS-0005	79RPS-0006
Ag AA	-2	-2	-2	-2	-2	-2
As AA	38 M	8 M	23 M	29 M	23 M	22 M
Au AA	8 B	15 B	7 B	-2 B	-2 B	2 B
Ba AA	100	160	30	40	70	70
Co AA	68	40	38	43	35	30
Cr AA	675	610	184	208	25	146
Cu AA	98	110	138	117	105	99
Li AA	8	6	12	30	8	8
Ni AA	360	220	80	135	49	71
Pb AA	-10	-10	-10	-10	-10	-10
Sb AA	3.7M	1.3M	1.3M	1.1M	2.4M	2.9M
Zn AA	66	180	140	165	108	80
Be ICP/OES	-1	-1	-1	-1	-1	-1
Mo ICP/OES	-10	-10	-10	-10	-10	-10
Sc ICP/OES	2	2	2	2	2	2
Sr ICP/OES	40	45	150	40	135	130
V ICP/OES	155	160	240	230	290	260
Y ICP/OES	4	5	10	9	18	10
Ga XRF	12	8	15	11	17	15
Nb XRF	5	5	5	5	5	5
Rb XRF	6	8	6	7	6	5
Zr XRF	19	23	20	30	35	35
Ce ICP-MS	-35	35	35	-35	50	-35
La ICP-MS	-30	-30	-30	-30	-30	-30

Nd

ICP-MS

20

-20

20

-20

-20

-20

MAJOR OXIDE LISTING

79RPS-0007 79RPS-0008 79RPS-0009 79RPS-0010 79RPS-0011 79RPS-0012

SiO2	47.80	50.20	48.40	56.90	48.80	49.00
Al2O3	14.90	10.90	13.80	11.20	15.30	16.20
Fe2O3	4.20	5.90	3.80	5.80	5.60	4.60
FeO	8.10	13.10	9.64	13.70	10.80	9.40
MgO	7.06	1.91	7.52	0.78	3.33	3.54
CaO	11.30	10.10	10.60	4.99	8.69	9.68
Na2O	1.58	1.46	1.30	2.10	3.00	2.38
K2O	00.00	0.46	0.11	0.23	0.74	0.34
TiO2	0.97	2.29	1.07	1.14	1.41	1.19
P2O5	0.01	0.10	0.02	0.37	0.03	0.04
MnO	0.18	0.29	0.20	0.27	0.21	0.19
CO2	0.19	1.15	0.23	0.75	0.19	0.22
S	0.11	0.03	0.07	0.12	0.01	0.13
H2O+	2.13	0.81	2.58	1.72	2.15	2.36
H2O-	0.11	0.09	0.13	0.13	0.05	0.05
LOI	2.50	1.20	2.70	1.50	1.40	2.10
TOTAL	98.60	98.80	99.50	100.20	100.30	99.30
S.G.	3.05	3.13	3.04	2.97	3.04	3.04

TRACE ELEMENT LISTING

METHOD 79RPS-0007 79RPS-0008 79RPS-0009 79RPS-0010 79RPS-0011 79RPS-0012

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	28 M	2 M	10 M	12 M	7 M	4 M
Au	AA	3 B	-2 B	2 B	7 B	-2 B	-2 B
Ba	AA	100	70	50	40	170	110
Co	AA	34	26	44	22	38	42
Cr	AA	273	6	275	5	6	9
Cu	AA	108	16	100	32	15	124
Li	AA	10	3	11	7	10	8
Ni	AA	95	-5	110	-5	18	28
Pb	AA	-10	-10	-10	-10	-10	-10
Sb	AA	4.8M	1.3M	1.2M	0.7M	0.8M	0.2M
Zn	AA	98	130	109	155	114	114
Be	ICP/OES	-1	-1	-1	-1	-1	-1
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sc	ICP/OES	2	2	2	2	2	2
Sr	ICP/OES	160	90	95	65	160	125
V	ICP/OES	270	30	290	13	390	340
Y	ICP/OES	16	35	15	75	30	25
Ga	XRF	18	28	12	31	26	21
Nb	XRF	5	5	5	5	5	5
Rb	XRF	4	7	11	8	27	19
Zr	XRF	35	55	40	175	60	55
Ce	ICP-MS	-35	55	50	85	-35	35
La	ICP-MS	-30	-30	-30	45	-30	-30
Nd	ICP-MS	30	25	30	45	-20	-20

MAJOR OXIDE LISTING

	79RPS-0013	79RPS-0014	79RPS-0015	79RPS-0016	81RPS-0110	81RPS-0111
SiO2	48.90	47.50	47.80	48.70	45.40	47.80
Al2O3	15.70	16.90	12.10	13.20	13.80	15.60
Fe2O3	4.00	4.35	4.90	2.63	1.60	3.96
FeO	9.32	8.42	14.10	8.26	9.35	7.01
MgO	4.84	4.31	4.23	6.97	7.49	7.63
CaO	9.77	11.60	9.84	9.63	6.40	12.40
Na2O	1.94	1.57	1.79	0.91	1.04	1.02
K2O	0.31	0.23	0.25	00.00	1.02	0.04
TiO2	1.10	1.07	1.58	0.84	0.79	0.71
P2O5	0.01	00.00	0.04	00.00	0.54	0.05
MnO	0.18	0.18	0.26	0.16	0.15	0.17
CO2	0.33	0.35	0.22	5.08	6.78	0.45
S	0.01	0.09	0.18	0.01	0.15	0.13
H2O+	2.38	2.08	1.94	3.98	4.24	2.93
H2O-	0.07	0.12	0.15	0.10	0.08	0.09
LOI	2.60	2.50	1.40	8.70	10.30	2.90
TOTAL	98.90	98.80	99.40	100.50	98.80	99.90
S.G.	3.02	3.07	3.11	2.84	2.82	3.07

TRACE ELEMENT LISTING

METHOD	79RPS-0013	79RPS-0014	79RPS-0015	79RPS-0016	81RPS-0110	81RPS-0111
Ag AA	-2	-2	-2	-2	-2	-2
As AA	1.5M	31 M	7 M	-1 M	67 M	32 M
Au AA	2 B	-2 B	-2 B	-2 B	-2 B	170 B
Ba AA	70	70	50	20	180	60
Co AA	41	34	55	35	48	47
Cr AA	30	14	5	275	192	251
Cu AA	41	134	166	16	111	101
Li AA	8	8	8	20	28	10
Ni AA	40	37	26	96	68	70
Pb AA	-10	-10	-10	-10	18	80
Sb AA	0.5M	0.7M	1.8M	1.1M	1.1M	1.1M
Zn AA	98	93	140	72	99	82
Be ICP/OES	-1	-1	-1	-1	1	1
Mo ICP/OES	-10	-10	-10	-10	-10	-10
Sc ICP/OES	2	2	2	2	30	23
Sr ICP/OES	115	105	85	90	40	85
V ICP/OES	290	340	520	240	245	250
Y ICP/OES	17	14	23	15	4	8
Ga XRF	17	21	23	14	7	13
Nb XRF	5	5	5	5	11	9
Rb XRF	19	16	10	5	30	-10
Zr XRF	25	23	35	30	9	7
Ce ICP-MS	-35	35	-35	-35	-35	-35
La ICP-MS	35	-30	-30	-30	-30	-30
Nd ICP-MS	25	30	25	-20	-20	-20

MAJOR OXIDE LISTING

	81RPS-0112	81RPS-0113	81RPS-0114	81RPS-0115	81RPS-0122	81RPS-0131
SiO ₂	48.30	48.30	48.40	48.30	45.70	48.10
Al ₂ O ₃	14.90	13.20	12.10	13.70	13.70	14.20
Fe ₂ O ₃	3.42	4.06	4.19	4.65	2.21	2.78
FeO	8.25	8.62	8.98	9.20	8.47	5.04
MgO	7.07	8.30	8.83	8.00	6.93	7.68
CaO	12.00	11.20	10.30	9.72	8.70	5.42
Na ₂ O	1.18	0.77	0.77	1.06	2.07	2.03
K ₂ O	0.04	0.04	0.10	0.07	0.03	1.28
TiO ₂	0.90	0.76	0.88	0.80	0.88	0.85
P ₂ O ₅	0.03	0.05	0.05	0.05	0.07	0.11
MnO	0.20	0.21	0.20	0.19	0.17	0.11
CO ₂	0.30	0.35	0.72	0.21	6.28	8.15
S	0.10	0.06	0.10	0.09	0.03	0.02
H ₂ O ⁺	2.72	2.88	3.16	3.26	4.15	2.84
H ₂ O ⁻	0.08	0.08	0.08	0.06	0.13	0.11
LOI	2.10	2.70	3.40	3.20	9.80	11.10
TOTAL	99.50	99.00	98.90	99.40	99.60	98.70
S.G.	3.07	3.06	3.02	3.03	2.76	2.80

TRACE ELEMENT LISTING

METHOD	81RPS-0112	81RPS-0113	81RPS-0114	81RPS-0115	81RPS-0122	81RPS-0131
Ag AA	-2	-2	-2	-2	-2	-2
As AA	30 M	48 M	64 M	19 M	8.5M	2 M
Au AA	-2 B	-2 B	-2 B	-2 B	-2 B	-2 B
Ba AA	70	60	60	130	40	530
Co AA	46	48	56	48	41	32
Cr AA	47	52	56	49	285	285
Cu AA	96	135	136	150	94	80
Li AA	8	10	12	12	22	22
Ni AA	34	42	44	82	100	110
Pb AA	47	27	41	31	47	10
Sb AA	2.7M	4.2M	4.2M	4.1M	3.5M	0.5M
Zn AA	98	104	94	112	98	55
Be ICP/OES	1	1	1	1	1	1
Mo ICP/OES	-10	-10	-10	-10	-10	-10
Sc ICP/OES	35	30	45	45	25	10
Sr ICP/OES	80	70	85	95	45	295
V ICP/OES	325	310	330	295	260	145
Y ICP/OES	11	9	15	18	12	5
Ga XRF	14	19	10	18	18	13
Nb XRF	15	12	15	15	12	3
Rb XRF	-10	-10	-10	-10	-10	20
Zr XRF	9	7	13	11	16	70
Ce ICP-MS	-35	-35	-35	-35	-35	-35
La ICP-MS	-30	-30	-30	-30	-30	-30
Nd ICP-MS	-20	-20	-20	-20	-20	-20

MAJOR OXIDE LISTING

81RPS-0160 81RPS-0253 81RPS-0254 81RPS-0255 81RPS-0256 81RPS-0257

SiO2	59.90	53.20	43.10	47.80	50.40	48.90
Al2O3	16.50	16.50	10.40	11.50	17.20	13.20
Fe2O3	5.89	2.89	6.68	4.43	3.96	3.99
FeO	1.10	5.11	14.80	10.90	6.13	9.49
MgO	4.96	5.56	4.87	7.77	4.18	6.67
CaO	1.01	9.94	10.40	10.20	11.00	11.40
Na2O	6.22	1.84	0.75	0.89	1.88	1.47
K2O	0.34	0.08	0.36	0.09	0.04	0.07
TiO2	0.76	0.70	3.14	1.00	0.89	1.09
P2O5	0.13	0.03	0.01	0.01	00.00	00.00
MnO	0.07	0.13	0.27	0.24	0.16	0.20
CO2	0.68	0.62	0.20	0.45	0.64	0.30
S	0.01	0.02	0.35	0.05	0.01	0.16
H2O+	2.27	2.76	2.89	3.01	2.34	2.40
H2O-	0.09	0.10	0.11	0.15	0.10	0.10
LOI	3.00	2.90	1.80	3.00	2.80	2.00
TOTAL	100.00	99.50	98.30	98.40	98.90	99.40
S.G.	2.72	2.96	3.22	3.07	3.00	3.08

TRACE ELEMENT LISTING

METHOD 81RPS-0160 81RPS-0253 81RPS-0254 81RPS-0255 81RPS-0256 81RPS-0257

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	2 M	8.5M	27 M	35 M	6.5M	14 M
Au	AA	-2 B	-2 B	10 B	6 B	-2 B	-2 B
Ba	AA	190	60	60	110	70	60
Co	AA	21	29	56	58	29	45
Cr	AA	56	50	-5	10	8	21
Cu	AA	36	82	138	116	33	114
Li	AA	24	8	10	8	6	7
Ni	AA	31	59	34	64	37	63
Pb	AA	27	11	-10	-10	-10	-10
Sb	AA	3 M	5.4M	5.4M	1.8M	1.8M	2.7M
Zn	AA	80	60	160	136	62	98
Be	ICP/OES	1	-1	2	1	-1	1
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sc	ICP/OES	7	30	75	70	35	55
Sr	ICP/OES	80	100	50	60	110	85
V	ICP/OES	130	150	795	325	190	385
Y	ICP/OES	3	10	21	15	13	15
Ga	XRF	17	17	17	16	20	23
Nb	XRF	2	5	45	8	8	8
Rb	XRF	10	-10	-10	-10	-10	-10
Zr	XRF	95	40	15	19	22	15
Ce	ICP-MS	-35	-35	-35	-35	-35	-35
La	ICP-MS	-30	-30	-30	-30	-30	-30
Nd	ICP-MS	-20	-20	-20	-20	-20	-20

MAJOR OXIDE LISTING

81RPS-0258 81RPS-0259 81RPS-0260 81RPS-0277 81RPS-0278 81RPS-0279

SiO2	47.60	47.00	44.90	48.10	47.40	48.80
Al2O3	10.90	15.00	13.00	13.10	13.10	13.50
Fe2O3	4.11	5.15	1.56	4.30	3.20	3.91
FeO	13.00	6.57	7.96	9.42	9.35	8.85
MgO	6.92	7.30	6.96	7.80	8.69	7.73
CaO	10.70	12.50	10.20	11.50	11.50	10.70
Na2O	0.96	0.49	1.85	0.98	1.30	1.17
K2O	0.37	0.02	0.01	0.04	0.06	0.04
TiO2	1.62	0.95	0.79	1.25	1.03	1.33
P2O5	00.00	0.02	0.01	00.00	00.00	0.01
MnO	0.23	0.18	0.16	0.21	0.19	0.18
CO2	0.41	0.65	7.81	0.41	0.78	0.37
S	0.30	0.23	0.05	0.16	0.12	0.12
H2O+	2.79	3.54	4.28	2.75	3.21	2.49
H2O-	0.07	0.12	0.12	0.05	0.07	0.11
LOI	2.30	3.80	11.30	2.30	2.80	2.60
TOTAL	100.00	99.70	99.70	100.00	100.00	99.30
S.G.	3.12	3.07	2.80	3.10	3.06	3.06

TRACE ELEMENT LISTING

METHOD 81RPS-0258 81RPS-0259 81RPS-0260 81RPS-0277 81RPS-0278 81RPS-0279

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	15 M	17 M	5.5M	2.5M	12 M	24 M
Au	AA	4 B	-2 B	4 B	-2 B	-2 B	-2 B
Ba	AA	90	50	60	40	50	70
Co	AA	57	49	37	47	46	44
Cr	AA	33	262	205	134	179	156
Cu	AA	320	158	120	143	154	124
Li	AA	10	14	23	8	6	10
Ni	AA	82	126	115	70	89	80
Pb	AA	-10	16	27	-10	-10	-10
Sb	AA	2.5M	2.5M	8.6M	1.9M	3.8M	3.6M
Zn	AA	136	92	84	110	91	99
Be	ICP/OES	2	-1	-1	1	1	1
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sc	ICP/OES	70	40	35	55	55	50
Sr	ICP/OES	60	110	55	75	85	110
V	ICP/OES	635	225	185	485	235	260
Y	ICP/OES	19	13	13	15	15	17
Ga	XRF	16	16	16	15	15	15
Nb	XRF	25	7	4	12	8	8
Rb	XRF	-10	-10	-10	-10	-10	-10
Zr	XRF	14	12	9	12	15	16
Ce	ICP-MS	-35	-35	-35	-35	-35	-35
La	ICP-MS	-30	-30	-30	-30	-30	-30
Nd	ICP-MS	-20	-20	-20	-20	-20	-20

MAJOR OXIDE LISTING

	81RPS-0280	81RPS-0281	81RPS-0267	81RPS-0268	81RPS-0271	83RPS-0144
SiO ₂	48.90	48.40	53.00	49.80	47.30	53.20
Al ₂ O ₃	12.40	12.70	11.60	12.50	13.80	15.90
Fe ₂ O ₃	3.20	3.69	1.33	7.37	4.64	3.31
FeO	9.57	9.28	9.79	9.35	7.30	6.33
MgO	8.96	8.92	3.49	5.74	6.33	7.20
CaO	10.70	11.30	7.15	7.13	11.10	5.55
Na ₂ O	1.39	1.16	0.74	1.86	0.64	3.05
K ₂ O	0.02	0.12	0.36	0.04	0.19	0.12
TiO ₂	0.92	0.97	1.19	1.73	1.14	0.96
P ₂ O ₅	0.01	00.00	0.08	0.04	0.01	0.06
MnO	0.19	0.21	0.32	0.19	0.19	0.14
CO ₂	0.71	0.38	8.38	0.70	3.49	0.15
S	0.04	0.02	0.03	0.13	0.07	0.01
H ₂ O+	2.89	2.96	2.81	3.05	3.30	3.57
H ₂ O-	0.07	0.08	0.05	0.07	0.10	0.04
LOI	2.70	2.60	9.90	3.00	6.70	3.70
TOTAL	100.00	100.40	100.30	99.80	99.60	99.60
S.G.	3.03	3.07	2.89	3.00	2.95	2.85

TRACE ELEMENT LISTING

METHOD	81RPS-0280	81RPS-0281	81RPS-0267	81RPS-0268	81RPS-0271	83RPS-0144
Ag AA	-2	-2	-2	-2	-2	-2
As AA	46 M	7.5M	2 M	5.5M	7.5M	18 M
Au AA	-2 B	-2 B	-2 B	-2 B	-2 B	4 B
Ba AA	30	60	170	40	110	100
Co AA	55	44	22	35	32	36
Cr AA	179	185	42	31	274	307
Cu AA	210	69	61	60	164	38
Li AA	8	10	18	8	11	29
Ni AA	90	91	31	27	69	155
Pb AA	-10	13	-10	-10	-10	-10
Sb AA	6.3M	8.4M	1.4M	2 M	5.3M	2.3M
Zn AA	108	124	200	129	109	106
Be ICP/OES	1	1	-1	2	1	-1
Mo ICP/OES	-10	-10	-10	-10	-10	-10
Sc ICP/OES	50	50	24	55	50	20
Sr ICP/OES	75	105	100	135	200	160
V ICP/OES	235	255	145	435	240	160
Y ICP/OES	12	13	7	30	19	12
Ga XRF	18	18	14	22	22	22
Nb XRF	6	8	-1	15	9	18
Rb XRF	-10	-10	10	-10	10	-10
Zr XRF	12	21	70	23	14	40
Sm ICP-MS						-15
Eu ICP-MS						-1 M
Gd ICP-MS						-5
Dy ICP-MS						8 M

Yb	ICP-MS						-1	M
Ce	ICP-MS	-35	-35	-35	-35	-35	45	
La	ICP-MS	-30	-30	-30	-30	-30	25	
Nd	ICP-MS	-20	-20	-20	-20	-20	-30	

x

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

42

	MEAN	STD. DEVIATION
SiO ₂	48.63	3.04
Al ₂ O ₃	13.83	1.79
Fe ₂ O ₃	4.00	1.30
FeO	8.83	2.55
MgO	6.50	2.21
CaO	9.73	2.41
Na ₂ O	1.57	0.95
K ₂ O	0.19	0.27
TiO ₂	1.07	0.47
P ₂ O ₅	0.05	0.10
MnO	0.19	0.05
CO ₂	1.74	2.63
S	0.09	0.08
H ₂ O+	2.87	0.78
H ₂ O-	0.11	0.07
LOI	4.12	3.10
TOTAL	99.39	0.61
S.G.	2.99	0.12

TRACE ELEMENT STATISTICS

	NO. OF SAMPLES	MEAN	STD. DEVIATION
Ag	42	-2.00	0.00
As	42	18.35	16.56
Au	42	4.48	26.49
Ba	42	89.76	81.73
Co	42	41.26	10.68
Cr	42	145.00	154.15
Cu	42	106.24	57.14
Li	42	12.07	6.84
Ni	42	76.62	62.23
Pb	42	2.50	21.67
Sb	42	2.76	2.02
Zn	42	109.24	31.77
Be	42	0.02	1.12
Mo	42	-10.00	0.00
Sc	42	26.21	23.70
Sr	42	99.52	48.39
V	42	278.29	143.36
Y	42	15.83	11.67
Ga	42	17.14	4.92
Nb	42	8.74	7.50
Rb	42	0.81	12.10
Zr	42	30.98	30.12
Sm	1	-15.00	0.00
Eu	1	-1.00	0.00
Gd	1	-5.00	0.00
Dy	1	8.00	0.00
Yb	1	-1.00	0.00
Ce	42	-17.38	34.89
La	42	-25.36	17.09
Nd	42	-10.00	20.30

SAGE
MAFIC VOLCANICS; CYCLE 2, AREA I

MAJOR OXIDE LISTING

	80RPS-0012	80RPS-0013	80RPS-0015	80RPS-0016	80RPS-0017	80RPS-0018
SiO ₂	42.40	47.00	49.60	39.80	49.80	49.80
Al ₂ O ₃	13.70	14.20	14.60	13.70	13.50	13.20
Fe ₂ O ₃	1.86	2.54	2.00	1.70	2.90	2.00
FeO	8.59	5.27	12.20	10.10	9.88	9.64
MgO	7.16	4.46	3.70	2.35	3.29	4.61
CaO	10.00	10.50	8.51	10.40	7.46	7.27
Na ₂ O	2.13	1.90	3.17	1.79	2.76	2.74
K ₂ O	00.00	0.09	00.00	0.70	0.26	00.00
TiO ₂	0.88	0.99	1.67	1.46	1.56	1.20
P ₂ O ₅	0.03	0.02	0.10	0.08	0.08	0.09
MnO	0.16	0.18	0.32	0.31	0.22	0.15
CO ₂	7.60	8.45	2.93	12.90	5.36	5.31
S	0.06	0.13	0.12	0.11	0.07	0.09
H ₂ O+	4.86	3.96	1.05	2.72	3.46	3.85
H ₂ O-	0.11	0.22	0.06	0.29	0.14	0.11
LOI	11.20	11.20	2.40	15.20	7.90	7.30
TOTAL	99.70	99.90	100.00	98.40	100.90	100.00
S.G.	2.78	2.79	2.97	2.91	2.82	2.81

TRACE ELEMENT LISTING

METHOD	80RPS-0012	80RPS-0013	80RPS-0015	80RPS-0016	80RPS-0017	80RPS-0018
Ag AA	-2	-2	-2	-2	-2	-2
As AA	31 M	18 M	12 M	46 M	17 M	17 M
Au AA	4 B	4 B	4 B	4 B	4 B	4 B
Ba AA	10	50	50	100	70	30
Co AA	42	47	50	44	40	48
Cr AA	255	279	42	47	39	33
Cu AA	74	116	115	151	82	130
Li AA	38	27	15	22	18	21
Ni AA	202	138	42	45	34	71
Pb AA	-10	-10	-10	-10	-10	-10
Sb AA	13.6M	1 M	3.5M	9.8M	13.1M	3.2M
Zn AA	110	93	130	124	145	121
Be ICP/OES	-1	-1	-1	-1	-1	-1
Mo ICP/OES	-5	-5	-5	-5	-5	-5
Sc ICP/OES	20	20	20	20	20	20
Sr ICP/OES	70	120	140	135	75	240
V ICP/OES	255	255	410	350	395	280
Y ICP/OES	5	6	21	10	16	16
Ga XRF	9	12	21	20	18	21
Nb XRF	18	18	18	18	18	18
Rb XRF	5	10	8	31	13	7
Zr XRF	45	45	95	80	65	100
Ce ICP-MS	-35	35	-35	-35	35	45
La ICP-MS	-30	-30	-30	-30	35	-30

Nd

ICP-MS

30

20

25

20

25

30

MAJOR OXIDE LISTING

	80RPS-0019	80RPS-0020	80RPS-0021	80RPS-0022	80RPS-0024	80RPS-0027
SiO ₂	46.70	49.70	48.90	49.40	44.80	51.60
Al ₂ O ₃	16.10	10.90	15.20	15.10	15.30	17.70
Fe ₂ O ₃	1.72	2.00	0.69	3.36	1.16	0.70
FeO	6.56	7.70	5.99	6.97	7.94	4.29
MgO	3.02	12.20	2.86	6.27	3.65	1.85
CaO	8.38	7.44	9.89	8.86	10.80	9.32
Na ₂ O	3.57	2.30	1.83	0.68	1.13	1.94
K ₂ O	0.30	00.00	0.51	0.02	1.35	0.77
TiO ₂	1.09	0.94	1.10	0.94	0.93	1.20
P ₂ O ₅	0.04	0.13	0.03	0.02	0.03	0.02
MnO	0.26	0.16	0.20	0.15	0.25	0.11
CO ₂	8.50	1.80	8.07	4.12	8.24	6.70
S	0.25	0.01	0.11	0.06	0.02	0.16
H ₂ O+	3.12	3.78	3.41	3.96	3.76	3.28
H ₂ O-	0.31	0.26	0.17	0.29	0.25	0.29
LOI	10.30	5.30	10.00	7.90	11.20	9.80
TOTAL	99.90	99.30	99.00	100.20	99.60	100.20
S.G.	2.81	2.87	2.79	2.81	2.81	2.80

TRACE ELEMENT LISTING

METHOD	80RPS-0019	80RPS-0020	80RPS-0021	80RPS-0022	80RPS-0024	80RPS-0027
Ag AA	-2	-2	-2	-2	-2	-2
As AA	20 M	35 M	28 M	58 M	177 M	315 M
Au AA	4 B	4 B	4 B	4 B	4 B	4 B
Ba AA	70	10	110	20	160	100
Co AA	65	55	43	52	54	52
Cr AA	268	780	297	284	253	313
Cu AA	71	78	110	74	128	102
Li AA	21	14	22	33	26	23
Ni AA	152	250	120	202	140	231
Pb AA	-10	-10	-10	-10	-10	-10
Sb AA	8.3M	9.3M	1.8M	4.3M	2.9M	5.4M
Zn AA	82	77	73	82	96	62
Be ICP/OES	-1	-1	-1	-1	-1	-1
Mo ICP/OES	-5	-5	-5	-5	-5	-5
Sc ICP/OES	20	20	20	20	20	20
Sr ICP/OES	125	105	130	100	100	170
V ICP/OES	280	200	130	100	270	245
Y ICP/OES	5	15	17	21	14	9
Ga XRF	21	14	10	14	14	12
Nb XRF	18	18	18	18	18	18
Rb XRF	7	5	26	7	59	30
Zr XRF	45	70	40	45	45	45
Ce ICP-MS	45	50	45	-35	40	65
La ICP-MS	-30	-30	-30	-30	-30	-30
Nd ICP-MS	30	25	-20	-20	-20	-20

MAJOR OXIDE LISTING

80RPS-0028 80RPS-0029 80RPS-0030 80RPS-0031 80RPS0018D 82RPS-0075

SiO2	49.30	51.80	50.90	47.40	50.00	59.00
Al2O3	14.90	18.30	14.80	15.60	13.10	16.90
Fe2O3	2.22	2.69	0.85	3.11	2.20	2.31
FeO	5.83	5.67	4.21	7.37	9.80	4.38
MgO	4.01	4.93	3.14	6.30	4.62	3.39
CaO	8.57	4.62	8.72	9.93	7.38	3.51
Na2O	2.12	4.43	3.16	0.94	3.00	4.92
K2O	0.07	00.00	0.09	00.00	00.00	0.76
TiO2	0.95	1.14	0.86	1.00	1.06	0.89
P2O5	0.02	0.03	0.03	0.03	0.10	0.09
MnO	0.18	0.13	0.17	0.18	0.16	0.10
CO2	7.19	1.69	10.80	3.44	5.44	0.64
S	0.04	0.16	0.29	0.09	0.09	0.01
H2O+	4.30	3.89	2.19	4.00	3.63	2.25
H2O-	0.44	0.31	0.14	0.49	0.12	0.08
LOI	10.60	4.90	11.40	7.70	7.50	2.60
TOTAL	100.10	99.80	100.30	100.10	100.70	99.20
S.G.	2.79	2.78	2.81	2.88	2.81	2.77

TRACE ELEMENT LISTING

METHOD 80RPS-0028 80RPS-0029 80RPS-0030 80RPS-0031 80RPS0018D 82RPS-0075

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	27 M	62 M	85 M	4.5M	4.5M	5.5M
Au	AA	4 B	4 B	4 B	4 B	4 B	-2 B
Ba	AA	70	30	70	20	30	170
Co	AA	34	62	41	51	46	21
Cr	AA	278	345	276	284	32	42
Cu	AA	96	250	101	92	128	40
Li	AA	33	26	21	28	20	14
Ni	AA	157	260	114	191	70	29
Pb	AA	-10	-10	-10	-10	-10	350
Sb	AA	1.8M	5.5M	2.1M	3.4M	3.4M	43.2M
Zn	AA	130	145	98	135	112	93
Be	ICP/OES	-1	-1	-1	-1	-1	1
Mo	ICP/OES	-5	-5	-5	-5	-5	-10
Sc	ICP/OES	20	20	20	20	20	13
Sr	ICP/OES	115	90	180	145	250	280
V	ICP/OES	250	330	240	270	295	95
Y	ICP/OES	14	16	5	21	19	15
Ga	XRF	12	22	16	16	16	21
Nb	XRF	18	18	18	18	18	11
Rb	XRF	30	5	7	6	6	18
Zr	XRF	45	55	55	50	105	70
Ce	ICP-MS	65	-35	45	-35	-35	90
La	ICP-MS	-30	-30	-30	-30	-30	-30
Nd	ICP-MS	-20	-20	-20	-20	-20	20

MAJOR OXIDE LISTING

82RPS-0076 82RPS-0077 82RPS-0078 82RPS-0079 82RPS-0080 81RPS-0261

SiO2	46.70	49.20	45.70	50.20	49.00	60.60
Al2O3	12.80	15.40	15.10	16.30	15.70	20.50
Fe2O3	4.55	3.28	4.33	3.48	4.44	2.49
FeO	8.25	8.33	9.35	6.57	8.03	8.33
MgO	6.73	4.28	7.16	4.56	4.49	0.31
CaO	7.85	10.60	8.20	11.90	12.20	0.42
Na2O	2.14	0.52	1.74	2.02	1.27	1.06
K2O	00.00	0.02	0.01	0.07	0.25	0.31
TiO2	0.91	0.91	1.05	0.94	1.10	1.70
P2O5	0.02	0.02	0.03	0.02	0.03	0.04
MnO	0.18	0.20	0.18	0.16	0.22	0.31
CO2	5.10	3.14	1.33	0.64	0.41	0.19
S	0.01	0.01	0.35	0.12	0.17	0.02
H2O+	3.70	4.01	4.23	2.41	2.27	3.07
H2O-	0.12	0.09	0.09	0.04	0.05	0.09
LOI	8.10	6.10	4.40	2.30	1.70	2.90
TOTAL	99.00	99.90	98.90	99.40	99.60	99.40
S.G.	2.82	2.93	2.95	3.02	3.07	2.99

TRACE ELEMENT LISTING

METHOD 82RPS-0076 82RPS-0077 82RPS-0078 82RPS-0079 82RPS-0080 81RPS-0261

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	12 M	26 M	3 M	13 M	12 M	160 M
Au	AA	2 B	8 B	5 B	2 B	20 B	-2 B
Ba	AA	20	30	30	50	110	70
Co	AA	37	42	44	44	42	33
Cr	AA	209	225	203	237	210	259
Cu	AA	103	52	104	50	102	18
Li	AA	14	9	4	6	5	6
Ni	AA	58	118	91	127	94	37
Pb	AA	540	1770	154	640	845	10
Sb	AA	125 M	286 M	44.9M	119 M	154 M	154 M
Zn	AA	130	96	92	78	91	84
Be	ICP/OES	1	1	1	1	1	2
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sc	ICP/OES	35	40	40	40	45	35
Sr	ICP/OES	100	130	120	120	135	60
V	ICP/OES	275	280	280	295	290	380
Y	ICP/OES	16	19	22	21	24	4
Ga	XRF	18	17	18	16	19	19
Nb	XRF	16	16	35	14	15	10
Rb	XRF	6	7	6	8	11	10
Zr	XRF	21	25	21	12	11	20
Ce	ICP-MS	-35	50	-35	40	-35	-35
La	ICP-MS	-30	-30	-30	40	-30	-30
Nd	ICP-MS	20	30	-20	25	-20	-20

MAJOR OXIDE LISTING

81RPS-0262 81RPS-0263 81RPS-0264 81RPS-0265 81RPS-0266 84RPS-0001

SiO2	48.90	48.70	56.10	51.20	58.10	48.80
Al2O3	16.10	15.50	16.10	15.10	13.40	13.80
Fe2O3	3.62	2.10	3.32	2.10	1.20	5.10
FeO	13.70	8.40	6.06	9.64	7.30	9.89
MgO	2.06	3.20	1.73	2.56	1.41	4.54
CaO	4.44	7.09	5.17	6.95	6.72	5.00
Na2O	0.96	4.63	1.49	1.43	0.96	3.06
K2O	0.33	0.04	0.48	0.25	0.35	00.00
TiO2	1.22	1.19	1.28	1.25	1.58	1.56
P2O5	00.00	0.01	00.00	00.00	0.03	0.06
MnO	0.21	0.20	0.16	0.19	0.21	0.18
CO2	3.78	5.80	4.20	5.56	5.65	2.11
S	0.04	0.06	0.18	0.10	0.18	0.09
H2O+	4.18	2.85	3.57	3.85	3.03	3.98
H2O-	0.14	0.09	0.11	0.07	0.05	0.12
LOI	7.30	7.60	6.70	8.00	7.40	5.30
TOTAL	99.70	99.90	99.90	100.30	100.20	98.30
S.G.	2.89	2.75	2.82	2.84	2.82	2.86

TRACE ELEMENT LISTING

METHOD 81RPS-0262 81RPS-0263 81RPS-0264 81RPS-0265 81RPS-0266 84RPS-0001

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	59 M	12 M	26 M	10 M	24 M	24 M
Au	AA	-2 B	12 B	5 B	5 B	-2 B	-2 B
Ba	AA	110	60	130	80	180	40
Co	AA	65	45	82	74	48	45
Cr	AA	219	203	183	169	75	87
Cu	AA	44	138	107	114	62	78
Li	AA	24	14	13	16	12	8
Ni	AA	158	126	127	210	55	49
Pb	AA	-10	-10	-10	12	12	15
Sb	AA	154 M	154 M	1.4M	3.8M	3.5M	3.5M
Zn	AA	180	95	74	120	80	145
Be	ICP/OES	1	1	1	1	1	2
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sc	ICP/OES	55	40	45	50	45	75
Sr	ICP/OES	105	40	100	70	115	95
V	ICP/OES	325	210	270	360	330	440
Y	ICP/OES	9	5	8	11	12	35
Ga	XRF	16	13	13	14	14	14
Nb	XRF	11	7	8	8	10	15
Rb	XRF	-10	-10	10	-10	10	6
Zr	XRF	21	16	16	16	25	25
Ce	ICP-MS	-35	-35	-35	-35	-35	-35
La	ICP-MS	-30	-30	-30	-30	-30	-30
Nd	ICP-MS	-20	-20	-20	-20	-20	-20

MAJOR OXIDE LISTING

	81RPS-0270	81RPS-0272	81RPS-0273	81RPS-0274	81RPS-0275	81RPS-0276
SiO2	53.50	48.30	43.10	50.50	48.20	46.70
Al2O3	15.70	12.90	11.90	13.00	13.50	15.00
Fe2O3	2.79	2.36	6.05	3.20	7.60	1.60
FeO	9.64	10.60	11.20	9.86	10.70	9.06
MgO	4.89	4.36	3.73	3.36	4.33	5.72
CaO	3.08	7.17	8.66	7.37	5.08	7.67
Na2O	1.52	2.42	2.17	2.83	2.91	2.09
K2O	1.23	0.04	0.02	0.02	0.02	0.30
TiO2	1.27	1.61	1.49	1.66	1.60	1.20
P2O5	0.01	0.04	0.04	0.04	0.03	0.02
MnO	0.19	0.23	0.31	0.27	0.16	0.19
CO2	1.67	5.77	6.40	4.10	2.58	6.27
S	0.02	0.13	0.08	0.10	0.06	0.04
H2O+	4.15	3.79	3.77	3.48	3.35	3.67
H2O-	0.05	0.05	0.07	0.10	0.05	0.05
LOI	5.20	7.90	8.50	6.40	4.50	9.30
TOTAL	99.70	99.80	99.00	100.00	100.10	99.60
S.G.	2.82	2.82	2.89	2.84	2.91	2.81

TRACE ELEMENT LISTING

METHOD	81RPS-0270	81RPS-0272	81RPS-0273	81RPS-0274	81RPS-0275	81RPS-0276
Ag	AA -2	-2	-2	-2	-2	-2
As	AA 24 M	7 M	7 M	7 M	7 M	1.5M
Au	AA -2 B	-2 B	-2 B	-2 B	-2 B	-2 B
Ba	AA 250	40	30	50	50	120
Co	AA 39	52	33	35	35	38
Cr	AA 293	39	36	39	80	268
Cu	AA 45	148	56	96	50	158
Li	AA 12	10	10	11	8	25
Ni	AA 112	39	36	35	44	103
Pb	AA 18	-10	-10	11	10	-10
Sb	AA 3.5M	1 M	1 M	1 M	1 M	2.5M
Zn	AA 120	148	128	126	135	109
B	ICP/OES 100	100	100	100	100	100
Be	ICP/OES 1	1	1	1	2	1
Mo	ICP/OES -10	-10	-10	-10	-10	-10
Sc	ICP/OES 52	50	50	55	60	45
Sr	ICP/OES 45	65	95	130	75	85
V	ICP/OES 370	385	350	325	490	220
Y	ICP/OES 16	20	30	30	25	5
Ga	XRF 14	13	13	13	13	13
Nb	XRF 11	10	12	12	20	6
Rb	XRF 30	-10	-10	-10	-10	-10
Zr	XRF 8	45	24	16	14	23
Ce	ICP-MS 41	41	41	41	41	41
La	ICP-MS -30	-30	-30	-30	-30	-30
Nd	ICP-MS -20	-20	-20	-20	-20	-20

MAJOR OXIDE LISTING

	81RPS-0288	81RPS-0289	81RPS-0290	81RPS-0291	81RPS-0292
SiO ₂	45.80	50.10	53.20	51.30	50.40
Al ₂ O ₃	13.40	16.20	15.00	15.60	15.20
Fe ₂ O ₃	3.52	1.79	1.79	1.83	0.91
FeO	8.84	8.25	6.87	7.60	6.94
MgO	7.69	5.36	3.99	4.21	3.45
CaO	7.00	5.20	6.09	5.86	8.71
Na ₂ O	1.07	3.15	1.80	3.32	2.14
K ₂ O	00.00	0.31	0.14	0.67	0.35
TiO ₂	1.09	1.18	1.04	1.15	1.08
P ₂ O ₅	0.02	0.02	00.00	00.00	0.01
MnO	0.14	0.19	0.17	0.16	0.24
CO ₂	5.69	3.99	4.36	4.57	6.48
S	0.09	0.09	0.11	0.08	0.06
H ₂ O+	4.79	4.03	4.20	3.10	3.66
H ₂ O-	0.21	0.10	00.00	0.10	0.06
LOI	9.60	7.10	7.40	7.60	9.50
TOTAL	99.30	99.90	98.80	99.60	99.70
S.G.	2.81	2.79	2.80	2.78	2.80

TRACE ELEMENT LISTING

METHOD	81RPS-0288	81RPS-0289	81RPS-0290	81RPS-0291	81RPS-0292
Ag AA	-2	-2	-2	-2	-2
As AA	2 M	47 M	15 M	112 M	136 M
Au AA	-2 B	-2 B	-2 B	-2 B	-2 B
Ba AA	50	80	60	110	100
Co AA	35	38	25	47	57
Cr AA	267	299	278	306	282
Cu AA	93	109	102	99	130
Li AA	38	25	20	16	21
Ni AA	69	76	107	146	120
Pb AA	51	30	73	57	33
Sb AA	7.8M	2.4M	2.9M	3.3M	3.8M
Zn AA	102	80	100	112	72
B ICP/OES	100	100	100	100	100
Be ICP/OES	1	1	1	1	1
Mo ICP/OES	-10	-10	-10	-10	-10
Sc ICP/OES	50	55	50	50	45
Sr ICP/OES	40	45	95	50	85
V ICP/OES	235	245	205	225	200
Y ICP/OES	7	7	15	7	6
Ga XRF	13	13	13	13	13
Nb XRF	6	8	6	7	5
Rb XRF	10	10	-10	30	10
Zr XRF	18	12	6	12	8
Ce ICP-MS	41	41	41	41	41
La ICP-MS	-30	-30	-30	-30	-30
Nd ICP-MS	-20	-20	-20	-20	-20

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

41

	MEAN	STD. DEVIATION
SiO2	49.57	4.05
Al2O3	14.88	1.75
Fe2O3	2.67	1.44
FeO	8.19	2.12
MgO	4.29	2.05
CaO	7.56	2.46
Na2O	2.22	1.05
K2O	0.25	0.33
TiO2	1.19	0.26
P2O5	0.04	0.03
MnO	0.20	0.05
CO2	4.85	2.83
S	0.10	0.07
H2O+	3.53	0.74
H2O-	0.15	0.11
LOI	7.44	2.89
TOTAL	99.69	0.55
S.G.	2.84	0.07

TRACE ELEMENT STATISTICS

NO. OF SAMPLES		MEAN	STD. DEVIATION
Ag	41	-2.00	0.00
As	41	41.68	60.75
Au	41	2.32	4.49
Ba	41	73.66	51.51
Co	41	45.90	12.02
Cr	41	210.07	137.29
Cu	41	97.46	40.95
Li	41	18.27	8.78
Ni	41	111.83	63.95
Pb	41	107.34	325.52
Sb	41	33.39	64.33
Zn	41	107.44	26.49
B	11	100.00	0.00
Be	41	0.24	1.09
Mo	41	-7.93	2.49
Sc	41	35.61	15.78
Sr	41	111.46	53.33
V	41	283.78	83.93
Y	41	14.61	7.80
Ga	41	15.22	3.27
Nb	41	14.27	5.74
Rb	41	8.63	14.58
Zr	41	36.95	26.37
Ce	41	12.34	41.34
La	41	-26.71	14.73
Nd	41	-6.83	20.85

SAGE

INT-FELSIC VOLCS; N. OF WAWA LK.; WITHOUT LUCY MINE

MAJOR OXIDE LISTING

	79RPS-6435	79RPS-6436	79RPS-6437	79RPS-6438	79RPS-6439	79RPS-6440
SiO ₂	72.40	77.60	76.90	76.80	78.70	75.10
Al ₂ O ₃	13.60	11.40	11.10	11.30	11.80	11.90
Fe ₂ O ₃	0.77	0.62	0.87	0.26	1.30	0.64
FeO	1.00	0.58	1.16	0.83	0.50	1.00
MgO	0.76	0.75	1.01	1.24	0.86	1.14
CaO	1.26	0.74	1.25	1.44	0.60	1.57
Na ₂ O	2.79	0.85	00.00	0.03	00.00	1.28
K ₂ O	3.26	3.15	3.50	3.56	3.63	3.09
TiO ₂	0.22	0.11	0.11	0.14	0.14	0.13
P ₂ O ₅	00.00	00.00	00.00	00.00	00.00	00.00
MnO	0.05	0.04	0.04	0.04	0.04	0.06
CO ₂	1.87	1.22	2.02	2.39	1.13	2.61
S	0.01	0.05	0.26	0.01	0.09	0.01
H ₂ O+	0.53	0.89	0.64	0.63	1.18	0.82
H ₂ O-	0.10	0.20	0.19	0.18	0.16	0.15
LOI	2.60	2.60	3.40	3.70	2.60	3.70
TOTAL	98.60	98.20	99.10	98.90	100.10	99.50
S.G.	2.69	2.72	2.74	2.73	2.73	2.72

TRACE ELEMENT LISTING

METHOD	79RPS-6435	79RPS-6436	79RPS-6437	79RPS-6438	79RPS-6439	79RPS-6440
Ag AA	-2	-2	-2	-2	-2	-2
As AA	-1 M	8.5M	-1 M	-1 M	1 M	4 M
Au AA	-2 B	-2 B	-2 B	-2 B	-2 B	-2 B
Ba AA	600	520	420	600	260	420
Co AA	-5	-5	-5	-5	-5	-5
Cr AA	-5	-5	-5	-5	-5	-5
Cu AA	-5	6	20	-5	-5	-5
Li AA	10	15	18	14	15	16
Ni AA	-5	-5	-5	-5	-5	-5
Pb AA	-10	-10	-10	16	-10	14
Sb AA	0.7M	1 M	1.3M	0.6M	0.9M	0.7M
Zn AA	47	90	120	39	66	52
B ICP/OES	100	100	100	100	100	100
Be ICP/OES	-1	-1	-1	-1	-1	-1
Mo ICP/OES	-5	-5	-5	-5	-5	-5
Sc ICP/OES	1	1	1	1	1	1
Sr ICP/OES	45	19	25	30	8	32
V ICP/OES	13	10	9	10	11	10
Y ICP/OES	19	22	30	35	20	23
Ga XRF	-3	-3	-3	-3	-3	-3
Nb XRF	1	1	1	1	1	1
Rb XRF	50	50	50	50	50	50
Zr XRF	175	195	255	225	265	265

MAJOR OXIDE LISTING

	79RPS-6441	79RPS-6442	79RPS-6443	79RPS-6444	79RPS-6445	79RPS-6446
SiO ₂	73.80	76.00	75.40	79.10	78.70	76.10
Al ₂ O ₃	11.70	12.40	11.90	12.00	10.40	13.30
Fe ₂ O ₃	0.40	0.31	1.51	0.49	0.52	0.52
FeO	1.50	0.83	1.00	0.83	0.92	0.75
MgO	1.41	1.26	1.66	0.92	0.92	1.09
CaO	2.37	1.72	1.46	0.63	1.53	1.20
Na ₂ O	0.70	00.00	0.03	00.00	0.54	00.00
K ₂ O	3.16	3.58	3.26	3.52	2.75	4.12
TiO ₂	0.12	0.11	0.12	0.13	0.11	0.13
P ₂ O ₅	00.00	00.00	00.00	00.00	00.00	00.00
MnO	0.08	0.04	0.04	0.03	0.04	0.03
CO ₂	3.96	2.77	2.38	1.45	2.04	1.99
S	0.01	0.01	0.01	0.01	0.01	0.01
H ₂ O+	1.05	1.46	1.57	1.30	0.78	1.07
H ₂ O-	0.18	0.17	0.18	0.13	0.11	0.10
LOI	5.00	4.40	4.20	3.00	3.30	3.60
TOTAL	100.40	100.60	100.50	100.50	99.40	100.40
S.G.	2.73	2.73	2.73	2.73	2.75	2.74

TRACE ELEMENT LISTING

	METHOD	79RPS-6441	79RPS-6442	79RPS-6443	79RPS-6444	79RPS-6445	79RPS-6446
Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	-1 M	-1 M	2 M	-1 M	2.5M	-1 M
Au	AA	-2 B	-2 B	-2 B	-2 B	-2 B	-2 B
Ba	AA	320	350	340	370	320	490
Co	AA	-5	-5	-5	-5	-5	-5
Cr	AA	-5	-5	5	-5	-5	-5
Cu	AA	-5	-5	-5	8	-5	-5
Li	AA	12	10	12	8	20	12
Ni	AA	-5	-5	-5	-5	-5	-5
Pb	AA	11	30	-10	-10	24	-10
Sb	AA	0.7M	0.8M	0.7M	0.7M	0.6M	0.7M
Zn	AA	88	40	44	27	40	58
B	ICP/OES	100	100	100	100	100	100
Be	ICP/OES	-1	-1	-1	-1	-1	-1
Mo	ICP/OES	-5	-5	-5	-5	-5	-5
Sc	ICP/OES	1	1	1	1	1	1
Sr	ICP/OES	40	23	40	25	55	30
V	ICP/OES	11	10	9	8	11	13
Y	ICP/OES	18	19	15	22	22	25
Ga	XRF	-3	-3	-3	-3	-3	14
Nb	XRF	1	1	1	1	1	1
Rb	XRF	50	50	50	50	50	85
Zr	XRF	230	240	245	225	195	220
Ce	ICP-MS						120
La	ICP-MS						55
Nd	ICP-MS						42

MAJOR OXIDE LISTING

79RPS-6447 81RPS-0105 81RPS-0106 81RPS-0107 81RPS-0108 81RPS-0109

SiO2	75.10	77.60	74.40	75.70	76.90	74.70
Al2O3	11.80	13.30	11.30	13.50	13.00	13.10
Fe2O3	0.62	0.60	0.77	0.93	0.19	0.32
FeO	1.16	0.51	1.10	0.58	0.51	0.66
MgO	1.27	0.47	1.19	0.93	0.73	1.04
CaO	2.13	0.23	1.97	0.77	0.93	1.09
Na2O	00.00	0.80	0.34	0.32	1.76	0.89
K2O	3.63	3.51	3.54	4.35	2.59	4.65
TiO2	0.12	0.11	0.10	0.19	0.18	0.16
P2O5	00.00	0.02	0.03	0.04	0.03	0.03
MnO	0.09	0.01	0.06	0.01	0.02	0.03
CO2	3.54	0.30	3.59	1.17	1.40	1.72
S	0.01	0.02	0.01	0.02	0.01	0.01
H2O+	1.02	1.70	1.71	1.94	1.41	1.13
H2O-	0.12	0.10	0.09	0.10	0.09	0.07
LOI	4.80	1.80	4.90	3.40	2.90	2.90
TOTAL	100.60	99.30	100.20	100.50	99.80	99.60
S.G.	2.74	2.71	2.74	2.73	2.69	2.69

TRACE ELEMENT LISTING

METHOD 79RPS-6447 81RPS-0105 81RPS-0106 81RPS-0107 81RPS-0108 81RPS-0109

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	-1 M	-1 M	-1 M	87 M	-1 M	4.5M
Au	AA	-2 B	-2 B	2 B	-2 B	45 B	-2 B
Ba	AA	300	590	330	690	580	1080
Co	AA	-5	-5	-5	-5	-5	-5
Cr	AA	-5	-5	-5	-5	-5	-5
Cu	AA	-5	8	-5	6	-5	-5
Li	AA	10	20	10	22	10	20
Ni	AA	-5	-5	-5	-5	-5	-5
Pb	AA	-10	31	-10	12	-10	25
Sb	AA	1 M	0.8M	1.1M	1.1M	1.9M	2.2M
Zn	AA	107	64	34	22	18	25
B	ICP/OES	100	100	100	100	100	100
Be	ICP/OES	-1	2	1	1	1	1
Mo	ICP/OES	-5	-10	-10	-10	-10	-10
Sc	ICP/OES	1	2	2	2	3	4
Sr	ICP/OES	23	13	17	18	20	30
V	ICP/OES	11	1	1	2	2	2
Y	ICP/OES	27	4	12	2	4	9
Ga	XRF	11	11	11	13	13	11
Nb	XRF	1	1	4	-1	-1	3
Rb	XRF	75	100	90	100	70	90
Zr	XRF	255	155	180	145	115	140
Ce	ICP-MS	115	115	115	115	115	115
La	ICP-MS	-30	-30	-30	-30	-30	-30
Nd	ICP-MS	48	48	48	48	48	48

MAJOR OXIDE LISTING

81RPS-0116 81RPS-0117 81RPS-0118 81RPS-0119 81RPS-0120 81RPS-0123

SiO2	78.40	78.30	75.40	73.30	73.90	75.80
Al2O3	12.10	11.60	12.60	13.80	11.90	12.20
Fe2O3	0.36	0.76	0.34	0.72	0.51	0.90
FeO	0.88	1.17	0.88	0.95	1.10	0.95
MgO	1.00	1.23	1.29	1.54	1.63	1.07
CaO	0.91	0.61	1.47	1.45	1.91	1.26
Na2O	0.34	0.34	0.38	0.33	0.36	0.33
K2O	3.18	3.39	3.48	3.38	3.35	3.43
TiO2	0.16	0.17	0.16	0.19	0.15	0.15
P2O5	0.04	0.04	0.03	0.03	0.03	0.04
MnO	0.01	0.01	0.02	0.03	0.04	0.04
CO2	1.37	0.90	2.27	1.99	2.92	2.25
S	0.01	0.03	0.01	0.01	0.01	0.02
H2O+	1.75	1.85	1.73	1.83	1.67	1.63
H2O-	0.07	0.07	0.05	0.12	0.07	0.07
LOI	3.00	2.40	3.60	3.70	4.30	3.70
TOTAL	100.50	100.40	100.10	99.70	99.50	100.10
S.G.	2.72	2.73	2.73	2.73	2.73	2.73

TRACE ELEMENT LISTING

METHOD 81RPS-0116 81RPS-0117 81RPS-0118 81RPS-0119 81RPS-0120 81RPS-0123

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	1.5M	2 M	1.5M	2.5M	-1 M	-1 M
Au	AA	-2 B	-2 B	-2 B	-2 B	-2 B	-2 B
Ba	AA	180	240	170	370	390	270
Co	AA	-5	-5	-5	-5	-5	-5
Cr	AA	-5	-5	-5	7	-5	-5
Cu	AA	16	30	13	11	-5	6
Li	AA	6	12	7	12	8	8
Ni	AA	-5	-5	-5	-5	-5	-5
Pb	AA	30	28	49	88	33	27
Sb	AA	0.9M	1.8M	4.2M	4.2M	0.7M	1 M
Zn	AA	27	44	29	34	34	26
B	ICP/OES	100	100	100	100	100	100
Be	ICP/OES	1	1	1	1	1	1
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sc	ICP/OES	4	2	2	3	5	1
Sr	ICP/OES	19	5	20	19	16	14
V	ICP/OES	3	14	4	7	4	4
Y	ICP/OES	7	-1	1	4	6	2
Ga	XRF	9	10	10	10	9	10
Nb	XRF	-1	-1	-1	-1	-1	-1
Rb	XRF	90	90	90	80	150	80
Zr	XRF	155	-1	150	155	160	130
Ce	ICP-MS	115	115	115	115	115	115
La	ICP-MS	-30	-30	-30	-30	-30	-30
Nd	ICP-MS	48	48	48	48	48	48

MAJOR OXIDE LISTING

	81RPS-0124	81RPS-0125	81RPS-0126	81RPS-0127	81RPS-0128	81RPS-0129
SiO2	76.40	74.40	63.70	67.80	72.50	80.70
Al2O3	12.20	11.20	15.50	12.60	14.60	9.37
Fe2O3	0.67	0.29	1.58	0.88	0.80	1.21
FeO	0.58	1.39	3.36	2.48	0.73	0.44
MgO	1.06	2.58	3.67	2.87	1.05	1.02
CaO	1.23	2.14	1.50	2.83	0.81	0.38
Na2O	0.32	0.34	4.30	1.22	4.42	0.67
K2O	3.86	2.64	1.23	2.11	2.26	2.54
TiO2	0.15	0.15	0.54	0.31	0.21	0.20
P2O5	0.04	0.03	0.07	0.05	0.03	0.03
MnO	0.04	0.04	0.06	0.06	0.02	0.01
CO2	1.89	3.37	1.97	4.26	1.10	0.53
S	0.01	0.01	0.01	0.01	0.01	0.16
H2O+	1.62	1.78	2.15	1.77	1.10	1.59
H2O-	0.05	0.07	0.09	0.11	0.08	0.14
LOI	3.20	5.20	4.00	5.50	1.90	2.50
TOTAL	100.10	100.40	99.80	99.40	99.70	99.00
S.G.	2.74	2.73	2.72	2.73	2.68	2.70

TRACE ELEMENT LISTING

METHOD	81RPS-0124	81RPS-0125	81RPS-0126	81RPS-0127	81RPS-0128	81RPS-0129
Ag	AA -2	-2	-2	-2	-2	-2
As	AA -1 M	1 M	1 M	1.5M	2 M	1 M
Au	AA -2 B	-2 B	-2 B	-2 B	-2 B	-2 B
Ba	AA 410	550	380	570	520	620
Co	AA -5	-5	16	7	-5	-5
Cr	AA -5	-5	35	10	-5	7
Cu	AA -5	-5	6	15	13	18
Li	AA 14	13	20	20	13	20
Ni	AA -5	-5	26	10	-5	-5
Pb	AA 37	14	10	59	39	113
Sb	AA 0.5M	0.7M	1.1M	0.4M	0.4M	0.7M
Zn	AA 30	34	48	48	34	24
B	ICP/OES 100	100	100	100	100	100
Be	ICP/OES 1	1	1	1	1	1
Mo	ICP/OES -10	-10	-10	-10	-10	-10
Sc	ICP/OES 2	3	7	4	4	4
Sr	ICP/OES 16	30	95	65	70	25
V	ICP/OES 1	2	85	35	5	8
Y	ICP/OES 2	5	3	2	4	10
Ga	XRF 11	8	8	8	7	6
Nb	XRF -1	-1	1	-1	1	-1
Rb	XRF 100	60	30	50	70	60
Zr	XRF 140	130	125	85	195	120
Ce	ICP-MS 115	115	115	115	115	115
La	ICP-MS -30	-30	-30	-30	-30	-30
Nd	ICP-MS 48	48	48	48	48	48

MAJOR OXIDE LISTING

	81RPS-0130	83RPS-0130	83RPS-0131	83RPS-0132	83RPS-0133	83RPS-0134
SiO2	80.00	72.90	73.00	73.90	76.30	75.80
Al2O3	10.40	12.90	13.90	13.50	13.00	13.30
Fe2O3	0.70	0.68	0.54	0.64	0.49	0.31
FeO	0.51	1.67	0.95	1.24	1.16	0.73
MgO	0.75	0.38	0.24	0.58	0.48	0.70
CaO	0.80	2.00	1.46	1.51	1.13	1.27
Na2O	1.83	2.53	2.94	2.52	2.48	1.58
K2O	1.87	3.27	3.43	2.71	2.33	2.89
TiO2	0.18	0.24	0.30	0.23	0.28	0.28
P2O5	0.01	0.01	0.02	0.02	0.02	0.01
MnO	0.02	0.06	0.04	0.05	0.04	0.04
CO2	1.08	1.65	1.22	1.23	0.89	1.01
S	0.06	0.01	00.00	0.01	0.01	00.00
H2O+	1.19	1.28	1.05	1.41	1.31	1.45
H2O-	0.12	0.04	0.04	0.03	0.04	0.02
LOI	2.30	2.50	2.30	2.40	2.40	2.70
TOTAL	99.50	99.60	99.10	100.00	100.00	99.40
S.G.	2.68	2.70	2.70	2.70	2.70	2.42

TRACE ELEMENT LISTING

METHOD	81RPS-0130	83RPS-0130	83RPS-0131	83RPS-0132	83RPS-0133	83RPS-0134
Ag AA	-2	-2	-2	-2	-2	-2
As AA	-1 M	5 M	2.5M	8 M	2 M	1 M
Au AA	-2 B	6 B	-2 B	3 B	-2 B	11 B
Ba AA	430	700	810	530	300	610
Co AA	-5	-5	-5	-5	-5	-5
Cr AA	5	-5	6	-5	-5	-5
Cu AA	8	10	6	6	7	10
Li AA	15	6	6	8	5	8
Ni AA	-5	-5	-5	-5	-5	-5
Pb AA	46	68	27	16	11	18
Sb AA	0.7M	1.7M	1.2M	1.2M	0.7M	0.5M
Zn AA	23	420	200	108	93	64
B ICP/OES	100	100	100	100	100	100
Be ICP/OES	1	-1	-1	-1	-1	-1
Mo ICP/OES	-10	-10	-10	-10	-10	-10
Sc ICP/OES	4	3	3	3	4	2
Sr ICP/OES	35	50	50	40	40	50
V ICP/OES	5	5	6	5	7	4
Y ICP/OES	10	17	17	14	15	13
Ga XRF	-3	-3	-3	-3	-3	-3
Nb XRF	-1	4	5	4	6	-1
Rb XRF	50	70	80	80	60	100
Zr XRF	130	140	140	140	145	135
Sm ICP-MS		-15	-15	-15	-15	-15
Eu ICP-MS		-1 M	-1 M	-1 M	-1 M	-1 M
Gd ICP-MS		-5	-5	-5	-5	-5

Dy	ICP-MS		7 M	7 M	6 M	8 M	6 M
Yb	ICP-MS		-1 M	-1 M	-1 M	-1 M	-1 M
Ce	ICP-MS	115	45	50	40	75	-35
La	ICP-MS	-30	35	30	30	35	25
Nd	ICP-MS	48	-30	-30	-30	-30	-30

MAJOR OXIDE LISTING

83RPS-0135 83RPS-0136 83RPS-0137 83RPS-0138 83RPS-0139 83RPS-0140

SiO2	76.90	63.30	77.70	79.80	77.00	65.60
Al2O3	11.80	15.00	12.00	11.10	11.00	13.80
Fe2O3	0.36	0.90	0.70	0.53	0.58	1.29
FeO	1.89	4.44	0.76	1.09	0.87	4.95
MgO	0.60	2.64	1.02	0.38	0.91	2.65
CaO	1.85	3.06	1.59	0.85	2.75	2.58
Na2O	0.90	2.79	00.00	1.88	0.08	0.28
K2O	2.58	1.90	2.95	1.79	2.80	2.69
TiO2	0.26	0.66	0.14	0.16	0.15	0.82
P2O5	0.02	0.05	00.00	0.04	0.03	0.18
MnO	0.05	0.08	0.04	0.04	0.06	0.11
CO2	1.44	2.25	1.32	0.71	2.25	1.84
S	0.01	0.01	00.00	00.00	0.05	00.00
H2O+	1.39	2.41	1.67	1.25	1.57	2.71
H2O-	0.05	0.05	0.05	0.04	0.03	0.04
LOI	3.00	4.60	3.10	2.20	3.80	4.20
TOTAL	100.10	99.50	99.90	99.70	100.10	99.50
S.G.	2.72	2.75	2.72	2.70	2.72	2.78

TRACE ELEMENT LISTING

METHOD 83RPS-0135 83RPS-0136 83RPS-0137 83RPS-0138 83RPS-0139 83RPS-0140

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	1.5M	1 M	-1 M	-1 M	-1 M	-1 M
Au	AA	3 B	4 B	-2 B	2 B	5 B	4 B
Ba	AA	330	510	300	470	460	740
Co	AA	-5	18	-5	-5	-5	9
Cr	AA	-5	20	-5	-5	-5	5
Cu	AA	14	48	11	12	102	6
Li	AA	8	22	10	7	8	28
Ni	AA	-5	24	-5	-5	-5	-5
Pb	AA	18	-10	23	10	18	10
Sb	AA	0.6M	1.5M	1.9M	0.5M	0.6M	0.5M
Zn	AA	83	105	70	92	48	127
B	ICP/OES	100	100	100	100	100	100
Be	ICP/OES	-1	-1	-1	-1	-1	-1
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sc	ICP/OES	2	7	-1	-1	-1	8
Sr	ICP/OES	40	70	50	35	65	50
V	ICP/OES	5	70	1	-1	10	18
Y	ICP/OES	19	7	22	25	18	14
Ga	XRF	-3	-3	-3	-3	-3	-3
Nb	XRF	2	5	2	-1	-1	-1
Rb	XRF	80	60	90	60	90	70
Zr	XRF	180	100	150	165	165	165
Sm	ICP-MS	-15	-15	-15	-15	-15	-15
Eu	ICP-MS	-1 M	-1 M	-1 M	-1 M	-1 M	-1 M
Gd	ICP-MS	-5	-5	-5	-5	-5	-5

Dy	ICP-MS	6 M	5 M	7 M	7 M	7 M	5 M
Yb	ICP-MS	-1 M	-1 M	-1 M	-1 M	-1 M	-1 M
Ce	ICP-MS	-35	-35	70	55	50	-35
La	ICP-MS	30	25	45	40	30	40
Nd	ICP-MS	-30	-30	-30	-30	-30	-30

MAJOR OXIDE LISTING

83RPS-0141 83RPS-0142 83RPS-0143

SiO2	78.80	76.70	77.00
Al2O3	10.60	11.20	11.10
Fe2O3	0.49	1.03	0.91
FeO	0.73	0.80	1.53
MgO	0.98	0.95	0.69
CaO	1.72	1.77	1.87
Na2O	00.00	00.00	0.54
K2O	2.98	2.92	2.68
TiO2	0.12	0.14	0.27
P2O5	0.02	0.03	00.00
MnO	0.05	0.06	0.06
CO2	2.53	1.54	1.58
S	00.00	0.28	0.01
H2O+	1.18	1.63	1.65
H2O-	0.04	0.05	0.03
LOI	3.70	3.40	3.10
TOTAL	100.20	99.10	99.90
S.G.	2.73	2.72	2.73

TRACE ELEMENT LISTING

METHOD 83RPS-0141 83RPS-0142 83RPS-0143

Ag	AA	-2	-2	-2
As	AA	-1 M	4 M	23 M
Au	AA	-2 B	4 B	2 B
Ba	AA	470	470	260
Co	AA	-5	-5	-5
Cr	AA	-5	-5	-5
Cu	AA	6	11	6
Li	AA	-3	10	10
Ni	AA	-5	-5	-5
Pb	AA	11	49	-10
Sb	AA	0.3M	0.9M	1 M
Zn	AA	28	144	62
B	ICP/OES	100	100	100
Be	ICP/OES	-1	-1	-1
Mo	ICP/OES	-10	-10	-10
Sc	ICP/OES	-1	-1	2
Sr	ICP/OES	30	55	40
V	ICP/OES	-1	1	4
Y	ICP/OES	20	17	15
Ga	XRF	-3	-3	-3
Nb	XRF	2	-1	2
Rb	XRF	80	90	60
Zr	XRF	130	155	170
Sm	ICP-MS	-15	-15	-15
Eu	ICP-MS	-1 M	-1 M	-1 M
Gd	ICP-MS	-5	-5	-5

Dy	ICP-MS	6 M	6 M	6 M
Yb	ICP-MS	-1 M	-1 M	-1 M
Ce	ICP-MS	-35	-35	40
La	ICP-MS	35	35	35
Nd	ICP-MS	-30	-30	-30

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

45

	MEAN	STD. DEVIATION
SiO2	75.25	3.83
Al2O3	12.29	1.28
Fe2O3	0.68	0.32
FeO	1.19	0.93
MgO	1.17	0.70
CaO	1.46	0.65
Na2O	0.98	1.16
K2O	3.06	0.68
TiO2	0.20	0.14
P2O5	0.02	0.03
MnO	0.04	0.02
CO2	1.89	0.90
S	0.03	0.06
H2O+	1.43	0.45
H2O-	0.09	0.05
LOI	3.37	0.92
TOTAL	99.79	0.56
S.G.	2.72	0.05

TRACE ELEMENT STATISTICS

	NO. OF SAMPLES	MEAN	STD. DEVIATION
Ag	45	-2.00	0.00
As	45	3.37	13.38
Au	45	0.56	7.39
Ba	45	458.67	177.59
Co	45	-3.44	5.22
Cr	45	-1.78	7.82
Cu	45	7.98	17.94
Li	45	12.33	5.84
Ni	45	-3.33	6.57
Pb	45	19.89	27.11
Sb	45	1.06	0.81
Zn	45	68.00	65.99
B	45	100.00	0.00
Be	45	-0.18	1.03
Mo	45	-8.56	2.29
Sc	45	2.22	2.05
Sr	45	35.27	18.98
V	45	10.11	15.99
Y	45	13.69	8.85
Ga	45	2.49	6.63
Nb	45	0.82	1.92
Rb	45	71.78	22.01
Zr	45	166.20	52.40
Sm	14	-15.00	0.00
Eu	14	-1.00	0.00
Gd	14	-5.00	0.00
Dy	14	6.36	0.84
Yb	14	-1.00	0.00
Ce	34	74.12	57.74
La	34	-1.32	33.15
Nd	34	15.71	38.83

SAGE

INT-FELSIC VOLCS; N. OF WAWA LK.; WITH LUCY MINE

MAJOR OXIDE LISTING

	79RPS-6435	79RPS-6436	79RPS-6437	79RPS-6438	79RPS-6439	79RPS-6440
SiO ₂	72.40	77.60	76.90	76.80	78.70	75.10
Al ₂ O ₃	13.60	11.40	11.10	11.30	11.80	11.90
Fe ₂ O ₃	0.77	0.62	0.87	0.26	1.30	0.64
FeO	1.00	0.58	1.16	0.83	0.50	1.00
MgO	0.76	0.75	1.01	1.24	0.86	1.14
CaO	1.26	0.74	1.25	1.44	0.60	1.57
Na ₂ O	2.79	0.85	00.00	0.03	00.00	1.28
K ₂ O	3.26	3.15	3.50	3.56	3.63	3.09
TiO ₂	0.22	0.11	0.11	0.14	0.14	0.13
P ₂ O ₅	00.00	00.00	00.00	00.00	00.00	00.00
MnO	0.05	0.04	0.04	0.04	0.04	0.06
CO ₂	1.87	1.22	2.02	2.39	1.13	2.61
S	0.01	0.05	0.26	0.01	0.09	0.01
H ₂ O ⁺	0.53	0.89	0.64	0.63	1.18	0.82
H ₂ O ⁻	0.10	0.20	0.19	0.18	0.16	0.15
LOI	2.60	2.60	3.40	3.70	2.60	3.70
TOTAL	98.60	98.20	99.10	98.90	100.10	99.50
S.G.	2.69	2.72	2.74	2.73	2.73	2.72

TRACE ELEMENT LISTING

	METHOD	79RPS-6435	79RPS-6436	79RPS-6437	79RPS-6438	79RPS-6439	79RPS-6440
Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	-1 M	8.5M	-1 M	-1 M	1 M	4 M
Au	AA	-2 B	-2 B	-2 B	-2 B	-2 B	-2 B
Ba	AA	600	520	420	600	260	420
Co	AA	-5	-5	-5	-5	-5	-5
Cr	AA	-5	-5	-5	-5	-5	-5
Cu	AA	-5	6	20	-5	-5	-5
Li	AA	10	15	18	14	15	16
Ni	AA	-5	-5	-5	-5	-5	-5
Pb	AA	-10	-10	-10	16	-10	14
Sb	AA	0.7M	1 M	1.3M	0.6M	0.9M	0.7M
Zn	AA	47	90	120	39	66	52
B	ICP/OES	100	100	100	100	100	100
Be	ICP/OES	-1	-1	-1	-1	-1	-1
Mo	ICP/OES	-5	-5	-5	-5	-5	-5
Sc	ICP/OES	2	2	2	2	2	2
Sr	ICP/OES	45	19	25	30	8	32
V	ICP/OES	13	10	9	10	11	10
Y	ICP/OES	19	22	30	35	20	23
Ga	XRF	11	12	11	11	12	11
Nb	XRF	2	2	2	2	2	2
Rb	XRF	60	75	85	80	82	75
Zr	XRF	175	195	255	225	265	265
Ce	ICP-MS	110	130	95	100	105	130

La	ICP-MS	30	60	46	-30	32	30
Nd	ICP-MS	27	40	55	34	39	46

MAJOR OXIDE LISTING

79RPS-6441 79RPS-6442 79RPS-6443 79RPS-6444 79RPS-6445 79RPS-6446

SiO2	73.80	76.00	75.40	79.10	78.70	76.10
Al2O3	11.70	12.40	11.90	12.00	10.40	13.30
Fe2O3	0.40	0.31	1.51	0.49	0.52	0.52
FeO	1.50	0.83	1.00	0.83	0.92	0.75
MgO	1.41	1.26	1.66	0.92	0.92	1.09
CaO	2.37	1.72	1.46	0.63	1.53	1.20
Na2O	0.70	00.00	0.03	00.00	0.54	00.00
K2O	3.16	3.58	3.26	3.52	2.75	4.12
TiO2	0.12	0.11	0.12	0.13	0.11	0.13
P2O5	00.00	00.00	00.00	00.00	00.00	00.00
MnO	0.08	0.04	0.04	0.03	0.04	0.03
CO2	3.96	2.77	2.38	1.45	2.04	1.99
S	0.01	0.01	0.01	0.01	0.01	0.01
H2O+	1.05	1.46	1.57	1.30	0.78	1.07
H2O-	0.18	0.17	0.18	0.13	0.11	0.10
LOI	5.00	4.40	4.20	3.00	3.30	3.60
TOTAL	100.40	100.60	100.50	100.50	99.40	100.40
S.G.	2.73	2.73	2.73	2.73	2.75	2.74

TRACE ELEMENT LISTING

METHOD 79RPS-6441 79RPS-6442 79RPS-6443 79RPS-6444 79RPS-6445 79RPS-6446

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	-1 M	1 M	2 M	-1 M	2.5M	-1 M
Au	AA	-2 B	-2 B	-2 B	-2 B	-2 B	-2 B
Ba	AA	320	350	340	370	320	490
Co	AA	-5	-5	-5	-5	-5	-5
Cr	AA	-5	-5	5	-5	-5	-5
Cu	AA	-5	-5	-5	8	-5	-5
Li	AA	12	10	12	8	20	12
Ni	AA	-5	-5	-5	-5	-5	-5
Pb	AA	11	30	-10	-10	24	-10
Sb	AA	0.7M	0.8M	0.7M	0.7M	0.6M	0.7M
Zn	AA	88	40	44	27	40	58
B	ICP/OES	100	100	100	100	100	100
Be	ICP/OES	-1	-1	-1	-1	-1	-1
Mo	ICP/OES	-5	-5	-5	-5	-5	-5
Sc	ICP/OES	2	2	2	2	2	2
Sr	ICP/OES	40	23	40	25	55	30
V	ICP/OES	11	10	9	8	11	13
Y	ICP/OES	18	19	15	22	22	25
Ga	XRF	10	11	10	12	12	14
Nb	XRF	2	2	2	2	2	2
Rb	XRF	70	70	70	70	75	85
Zr	XRF	230	240	245	225	195	220
Ce	ICP-MS	125	130	105	155	155	120
La	ICP-MS	31	52	36	70	70	55
Nd	ICP-MS	44	41	34	55	55	42

MAJOR OXIDE LISTING

79RPS-6447 81RPS-0105 81RPS-0106 81RPS-0107 81RPS-0108 81RPS-0109

SiO2	75.10	77.60	74.40	75.70	76.90	74.70
Al2O3	11.80	13.30	11.30	13.50	13.00	13.10
Fe2O3	0.62	0.60	0.77	0.93	0.19	0.32
FeO	1.16	0.51	1.10	0.58	0.51	0.66
MgO	1.27	0.47	1.19	0.93	0.73	1.04
CaO	2.13	0.23	1.97	0.77	0.93	1.09
Na2O	00.00	0.80	0.34	0.32	1.76	0.89
K2O	3.63	3.51	3.54	4.35	2.59	4.65
TiO2	0.12	0.11	0.10	0.19	0.18	0.16
P2O5	00.00	0.02	0.03	0.04	0.03	0.03
MnO	0.09	0.01	0.06	0.01	0.02	0.03
CO2	3.54	0.30	3.59	1.17	1.40	1.72
S	0.01	0.02	0.01	0.02	0.01	0.01
H2O+	1.02	1.70	1.71	1.94	1.41	1.13
H2O-	0.12	0.10	0.09	0.10	0.09	0.07
LOI	4.80	1.80	4.90	3.40	2.90	2.90
TOTAL	100.60	99.30	100.20	100.50	99.80	99.60
S.G.	2.74	2.71	2.74	2.73	2.69	2.69

TRACE ELEMENT LISTING

METHOD 79RPS-6447 81RPS-0105 81RPS-0106 81RPS-0107 81RPS-0108 81RPS-0109

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	-1 M	-1 M	-1 M	87 M	-1 M	4.5M
Au	AA	-2 B	-2 B	2 B	-2 B	45 B	-2 B
Ba	AA	300	590	330	690	580	1080
Co	AA	-5	-5	-5	-5	-5	-5
Cr	AA	-5	-5	-5	-5	-5	-5
Cu	AA	-5	8	-5	6	-5	-5
Li	AA	10	20	10	22	10	20
Ni	AA	-5	-5	-5	-5	-5	-5
Pb	AA	-10	31	-10	12	-10	25
Sb	AA	1 M	0.8M	1.1M	1.1M	1.9M	2.2M
Zn	AA	107	64	34	22	18	25
B	ICP/OES	100	100	100	100	100	100
Be	ICP/OES	-1	2	1	1	1	1
Mo	ICP/OES	-5	-10	-10	-10	-10	-10
Sc	ICP/OES	2	2	2	2	3	4
Sr	ICP/OES	23	13	17	18	20	30
V	ICP/OES	11	1	1	2	2	2
Y	ICP/OES	27	4	12	2	4	9
Ga	XRF	11	11	9	13	13	11
Nb	XRF	2	1	4	-1	-1	3
Rb	XRF	75	100	90	100	70	90
Zr	XRF	255	155	180	145	115	140
Ce	ICP-MS	115	115	115	115	115	115
La	ICP-MS	-30	-30	-30	-30	-30	-30
Nd	ICP-MS	48	48	48	48	48	48

MAJOR OXIDE LISTING

81RPS-0116 81RPS-0117 81RPS-0118 81RPS-0119 81RPS-0120 81RPS-0123

SiO2	78.40	78.30	75.40	73.30	73.90	75.80
Al2O3	12.10	11.60	12.60	13.80	11.90	12.20
Fe2O3	0.36	0.76	0.34	0.72	0.51	0.90
FeO	0.88	1.17	0.88	0.95	1.10	0.95
MgO	1.00	1.23	1.29	1.54	1.63	1.07
CaO	0.91	0.61	1.47	1.45	1.91	1.26
Na2O	0.34	0.34	0.38	0.33	0.36	0.33
K2O	3.18	3.39	3.48	3.38	3.35	3.43
TiO2	0.16	0.17	0.16	0.19	0.15	0.15
P2O5	0.04	0.04	0.03	0.03	0.03	0.04
MnO	0.01	0.01	0.02	0.03	0.04	0.04
CO2	1.37	0.90	2.27	1.99	2.92	2.25
S	0.01	0.03	0.01	0.01	0.01	0.02
H2O+	1.75	1.85	1.73	1.83	1.67	1.63
H2O-	0.07	0.07	0.05	0.12	0.07	0.07
LOI	3.00	2.40	3.60	3.70	4.30	3.70
TOTAL	100.50	100.40	100.10	99.70	99.50	100.10
S.G.	2.72	2.73	2.73	2.73	2.73	2.73

TRACE ELEMENT LISTING

METHOD 81RPS-0116 81RPS-0117 81RPS-0118 81RPS-0119 81RPS-0120 81RPS-0123

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	1.5M	2 M	1.5M	2.5M	-1 M	-1 M
Au	AA	-2 B	-2 B	-2 B	-2 B	-2 B	-2 B
Ba	AA	180	240	170	370	390	270
Co	AA	-5	-5	-5	-5	-5	-5
Cr	AA	-5	-5	-5	7	-5	-5
Cu	AA	16	30	13	11	-5	6
Li	AA	6	12	7	12	8	8
Ni	AA	-5	-5	-5	-5	-5	-5
Pb	AA	30	28	49	88	33	27
Sb	AA	0.9M	1.8M	4.2M	4.2M	0.7M	1 M
Zn	AA	27	44	29	34	34	26
B	ICP/OES	100	100	100	100	100	100
Be	ICP/OES	1	1	1	1	1	1
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sc	ICP/OES	4	2	2	3	5	1
Sr	ICP/OES	19	5	20	19	16	14
V	ICP/OES	3	14	4	7	4	4
Y	ICP/OES	7	-1	1	4	6	2
Ga	XRF	9	10	10	10	9	10
Nb	XRF	-1	-1	-1	-1	-1	-1
Rb	XRF	90	90	90	80	150	80
Zr	XRF	155	-1	150	155	160	130
Ce	ICP-MS	115	115	115	115	115	115
La	ICP-MS	-30	-30	-30	-30	-30	-30
Nd	ICP-MS	48	48	48	48	48	48

MAJOR OXIDE LISTING

81RPS-0124 81RPS-0125 81RPS-0126 81RPS-0127 81RPS-0128 81RPS-0129

SiO2	76.40	74.40	63.70	67.80	72.50	80.70
Al2O3	12.20	11.20	15.50	12.60	14.60	9.37
Fe2O3	0.67	0.29	1.58	0.88	0.80	1.21
FeO	0.58	1.39	3.36	2.48	0.73	0.44
MgO	1.06	2.58	3.67	2.87	1.05	1.02
CaO	1.23	2.14	1.50	2.83	0.81	0.38
Na2O	0.32	0.34	4.30	1.22	4.42	0.67
K2O	3.86	2.64	1.23	2.11	2.26	2.54
TiO2	0.15	0.15	0.54	0.31	0.21	0.20
P2O5	0.04	0.03	0.07	0.05	0.03	0.03
MnO	0.04	0.04	0.06	0.06	0.02	0.01
CO2	1.89	3.37	1.97	4.26	1.10	0.53
S	0.01	0.01	0.01	0.01	0.01	0.16
H2O+	1.62	1.78	2.15	1.77	1.10	1.59
H2O-	0.05	0.07	0.09	0.11	0.08	0.14
LOI	3.20	5.20	4.00	5.50	1.90	2.50
TOTAL	100.10	100.40	99.80	99.40	99.70	99.00
S.G.	2.74	2.73	2.72	2.73	2.68	2.70

TRACE ELEMENT LISTING

METHOD 81RPS-0124 81RPS-0125 81RPS-0126 81RPS-0127 81RPS-0128 81RPS-0129

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	-1 M	1 M	1 M	1.5M	2 M	1 M
Au	AA	-2 B	-2 B	-2 B	-2 B	-2 B	-2 B
Ba	AA	410	550	380	570	520	620
Co	AA	-5	-5	16	7	-5	-5
Cr	AA	-5	-5	35	10	-5	7
Cu	AA	-5	-5	6	15	13	18
Li	AA	14	13	20	20	13	20
Ni	AA	-5	-5	26	10	-5	-5
Pb	AA	37	14	10	59	39	113
Sb	AA	0.5M	0.7M	1.1M	0.4M	0.4M	0.7M
Zn	AA	30	34	48	48	34	24
B	ICP/OES	100	100	100	100	100	100
Be	ICP/OES	1	1	1	1	1	1
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sc	ICP/OES	2	3	7	4	4	4
Sr	ICP/OES	16	30	95	65	70	25
V	ICP/OES	1	2	85	35	5	8
Y	ICP/OES	2	5	3	2	4	10
Ga	XRF	11	8	8	8	7	6
Nb	XRF	-1	-1	1	-1	1	-1
Rb	XRF	100	60	30	50	70	60
Zr	XRF	140	130	125	85	195	120
Ce	ICP-MS	115	115	115	115	115	115
La	ICP-MS	-30	-30	-30	-30	-30	-30
Nd	ICP-MS	48	48	48	48	48	48

MAJOR OXIDE LISTING

81RPS-0130 83RPS-0130 83RPS-0131 83RPS-0132 83RPS-0133 83RPS-0134

SiO2	80.00	72.90	73.00	73.90	76.30	75.80
Al2O3	10.40	12.90	13.90	13.50	13.00	13.30
Fe2O3	0.70	0.68	0.54	0.64	0.49	0.31
FeO	0.51	1.67	0.95	1.24	1.16	0.73
MgO	0.75	0.38	0.24	0.58	0.48	0.70
CaO	0.80	2.00	1.46	1.51	1.13	1.27
Na2O	1.83	2.53	2.94	2.52	2.48	1.58
K2O	1.87	3.27	3.43	2.71	2.33	2.89
TiO2	0.18	0.24	0.30	0.23	0.28	0.28
P2O5	0.01	0.01	0.02	0.02	0.02	0.01
MnO	0.02	0.06	0.04	0.05	0.04	0.04
CO2	1.08	1.65	1.22	1.23	0.89	1.01
S	0.06	0.01	00.00	0.01	0.01	00.00
H2O+	1.19	1.28	1.05	1.41	1.31	1.45
H2O-	0.12	0.04	0.04	0.03	0.04	0.02
LOI	2.30	2.50	2.30	2.40	2.40	2.70
TOTAL	99.50	99.60	99.10	100.00	100.00	99.40
S.G.	2.68	2.70	2.70	2.70	2.70	2.42

TRACE ELEMENT LISTING

METHOD 81RPS-0130 83RPS-0130 83RPS-0131 83RPS-0132 83RPS-0133 83RPS-0134

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	-1 M	5 M	2.5M	8 M	2 M	1 M
Au	AA	-2 B	6 B	-2 B	3 B	-2 B	11 B
Ba	AA	430	700	810	530	300	610
Co	AA	-5	-5	-5	-5	-5	-5
Cr	AA	5	-5	6	-5	-5	-5
Cu	AA	8	10	6	6	7	10
Li	AA	15	6	6	8	5	8
Ni	AA	-5	-5	-5	-5	-5	-5
Pb	AA	46	68	27	16	11	18
Sb	AA	0.7M	1.7M	1.2M	1.2M	0.7M	0.5M
Zn	AA	23	420	200	108	93	64
B	ICP/OES	100	100	100	100	100	100
Be	ICP/OES	1	-1	-1	-1	-1	-1
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sc	ICP/OES	4	3	3	3	4	2
Sr	ICP/OES	35	50	50	40	40	50
V	ICP/OES	5	5	6	5	7	4
Y	ICP/OES	10	17	17	14	15	13
Ga	XRF	-3	-3	-3	-3	-3	-3
Nb	XRF	-1	4	5	4	6	-1
Rb	XRF	50	70	80	80	60	100
Zr	XRF	130	140	140	140	145	135
Sm	ICP-MS		-15	-15	-15	-15	-15
Eu	ICP-MS		-1 M	-1 M	-1 M	-1 M	-1 M
Gd	ICP-MS		-5	-5	-5	-5	-5

Dy	ICP-MS		7 M	7 M	6 M	8 M	6 M
Yb	ICP-MS		-1 M	-1 M	-1 M	-1 M	-1 M
Ce	ICP-MS	115	45	50	40	75	-35
La	ICP-MS	-30	35	30	30	35	25
Nd	ICP-MS	48	-30	-30	-30	-30	-30

MAJOR OXIDE LISTING

	83RPS-0135	83RPS-0136	83RPS-0137	83RPS-0138	83RPS-0139	83RPS-0140
SiO2	76.90	63.30	77.70	79.80	77.00	65.60
Al2O3	11.80	15.00	12.00	11.10	11.00	13.80
Fe2O3	0.36	0.90	0.70	0.53	0.58	1.29
FeO	1.89	4.44	0.76	1.09	0.87	4.95
MgO	0.60	2.64	1.02	0.38	0.91	2.65
CaO	1.85	3.06	1.59	0.85	2.75	2.58
Na2O	0.90	2.79	00.00	1.88	0.08	0.28
K2O	2.58	1.90	2.95	1.79	2.80	2.69
TiO2	0.26	0.66	0.14	0.16	0.15	0.82
P2O5	0.02	0.05	00.00	0.04	0.03	0.18
MnO	0.05	0.08	0.04	0.04	0.06	0.11
CO2	1.44	2.25	1.32	0.71	2.25	1.84
S	0.01	0.01	00.00	00.00	0.05	00.00
H2O+	1.39	2.41	1.67	1.25	1.57	2.71
H2O-	0.05	0.05	0.05	0.04	0.03	0.04
LOI	3.00	4.60	3.10	2.20	3.80	4.20
TOTAL	100.10	99.50	99.90	99.70	100.10	99.50
S.G.	2.72	2.75	2.72	2.70	2.72	2.78

TRACE ELEMENT LISTING

METHOD	83RPS-0135	83RPS-0136	83RPS-0137	83RPS-0138	83RPS-0139	83RPS-0140
Ag AA	-2	-2	-2	-2	-2	-2
As AA	1.5M	1 M	-1 M	-1 M	-1 M	-1 M
Au AA	3 B	4 B	-2 B	2 B	5 B	4 B
Ba AA	330	510	300	470	460	740
Co AA	-5	18	-5	-5	-5	9
Cr AA	-5	20	-5	-5	-5	5
Cu AA	14	48	11	12	102	6
Li AA	8	22	10	7	8	28
Ni AA	-5	24	-5	-5	-5	-5
Pb AA	18	-10	23	10	18	10
Sb AA	0.6M	1.5M	1.9M	0.5M	0.6M	0.5M
Zn AA	83	105	70	92	48	127
B ICP/OES	100	100	100	100	100	100
Be ICP/OES	-1	-1	-1	-1	-1	-1
Mo ICP/OES	-10	-10	-10	-10	-10	-10
Sc ICP/OES	2	7	-1	-1	-1	8
Sr ICP/OES	40	70	50	35	65	50
V ICP/OES	5	70	1	-1	10	18
Y ICP/OES	19	7	22	25	18	14
Ga XRF	-3	-3	-3	-3	-3	-3
Nb XRF	2	5	2	-1	-1	-1
Rb XRF	80	60	90	60	90	70
Zr XRF	180	100	150	165	165	165
Sm ICP-MS	-15	-15	-15	-15	-15	-15
Eu ICP-MS	-1 M	-1 M	-1 M	-1 M	-1 M	-1 M
Gd ICP-MS	-5	-5	-5	-5	-5	-5

Dy	ICP-MS	6	M	5	M	7	M	7	M	5	M
Yb	ICP-MS	-1	M	-1	M	-1	M	-1	M	-1	M
Ce	ICP-MS	-35		-35		70		55		50	
La	ICP-MS	30		25		45		40		30	
Nd	ICP-MS	-30		-30		-30		-30		-30	

MAJOR OXIDE LISTING

83RPS-0141 83RPS-0142 83RPS-0143 83RPS-0145 83RPS-0146 83RPS-0147

SiO2	78.80	76.70	77.00	80.00	85.20	82.50
Al2O3	10.60	11.20	11.10	4.69	10.20	9.79
Fe2O3	0.49	1.03	0.91	0.56	0.27	0.51
FeO	0.73	0.80	1.53	4.29	0.36	0.44
MgO	0.98	0.95	0.69	1.13	0.06	0.31
CaO	1.72	1.77	1.87	1.80	0.01	0.45
Na2O	00.00	00.00	0.54	00.00	00.00	00.00
K2O	2.98	2.92	2.68	0.92	2.68	3.93
TiO2	0.12	0.14	0.27	0.26	0.20	0.24
P2O5	0.02	0.03	00.00	00.00	0.03	0.05
MnO	0.05	0.06	0.06	0.33	0.01	0.04
CO2	2.53	1.54	1.58	5.29	0.13	0.60
S	00.00	0.28	0.01	0.02	0.01	0.09
H2O+	1.18	1.63	1.65	0.72	1.37	1.10
H2O-	0.04	0.05	0.03	0.05	0.04	0.03
LOI	3.70	3.40	3.10	5.40	1.60	1.80
TOTAL	100.20	99.10	99.90	100.00	100.50	100.10
S.G.	2.73	2.72	2.73	2.76	2.68	2.69

TRACE ELEMENT LISTING

METHOD 83RPS-0141 83RPS-0142 83RPS-0143 83RPS-0145 83RPS-0146 83RPS-0147

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	-1 M	4 M	23 M	2.5M	8 M	4.5M
Au	AA	-2 B	4 B	2 B	-2 B	7 B	-2 B
Ba	AA	470	470	260	280	410	550
Co	AA	-5	-5	-5	-5	-5	-5
Cr	AA	-5	-5	-5	-5	-5	-5
Cu	AA	6	11	6	6	6	6
Li	AA	-3	10	10	4	4	12
Ni	AA	-5	-5	-5	-5	9	10
Pb	AA	11	49	-10	48	12	10
Sb	AA	0.3M	0.9M	1 M	2.1M	1.6M	1.7M
Zn	AA	28	144	62	51	21	40
B	ICP/OES	100	100	100	100	100	100
Be	ICP/OES	-1	-1	-1	-1	-1	-1
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sc	ICP/OES	-1	-1	2	3	3	2
Sr	ICP/OES	30	55	40	30	24	25
V	ICP/OES	-1	1	4	13	5	5
Y	ICP/OES	20	17	15	7	9	11
Ga	XRF	-3	-3	-3	-3	-3	-3
Nb	XRF	2	-1	2	2	-1	-1
Rb	XRF	80	90	60	30	70	70
Zr	XRF	130	155	170	80	130	120
Sm	ICP-MS	-15	-15	-15	-15	-15	-15
Eu	ICP-MS	-1 M	-1 M	-1 M	-1 M	-1 M	-1 M
Gd	ICP-MS	-5	-5	-5	-5	-5	-5

MAJOR OXIDE LISTING

83RPS-0148 83RPS-0149 83RPS-0150 83RPS-0151 83RPS-0152 83RPS-0153

SiO2	87.90	78.30	83.30	74.60	73.20	66.10
Al2O3	7.06	11.80	8.66	13.40	14.10	12.00
Fe2O3	00.00	0.04	0.27	0.76	1.10	1.02
FeO	0.44	0.22	0.87	0.87	0.44	1.89
MgO	0.05	0.02	0.31	0.61	0.05	0.68
CaO	0.10	0.13	0.73	1.12	0.70	5.47
Na2O	00.00	00.00	00.00	0.80	2.17	1.88
K2O	4.11	7.72	3.88	3.77	4.89	3.21
TiO2	0.18	0.29	0.17	0.33	0.34	0.32
P2O5	0.03	0.04	0.03	0.01	0.02	0.01
MnO	0.02	0.01	0.08	0.05	0.04	0.13
CO2	0.15	0.10	1.29	1.50	0.54	5.96
S	0.01	00.00	0.02	0.01	0.03	00.00
H2O+	0.36	0.55	0.83	1.56	1.01	1.11
H2O-	0.04	0.05	0.04	0.04	0.05	0.05
LOI	1.00	0.80	2.10	3.20	1.50	6.70
TOTAL	100.40	99.30	100.40	99.40	98.70	99.80
S.G.	2.64	2.63	2.69	2.73	2.66	2.72

TRACE ELEMENT LISTING

METHOD 83RPS-0148 83RPS-0149 83RPS-0150 83RPS-0151 83RPS-0152 83RPS-0153

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	10 M	2.5M	2 M	12 M	25 M	6.5M
Au	AA	6 B	13 B	20 B	-2 B	-2 B	-2 B
Ba	AA	890	850	670	570	560	510
Co	AA	-5	-5	-5	-5	8	-5
Cr	AA	-5	-5	-5	-5	-5	5
Cu	AA	6	15	8	11	20	8
Li	AA	6	8	10	19	10	8
Ni	AA	-5	-5	-5	7	12	-5
Pb	AA	14	10	16	-10	-10	15
Sb	AA	1.7M	1.5M	2.9M	1.3M	1.6M	2 M
Zn	AA	22	20	33	34	38	47
B	ICP/OES	100	100	100	100	100	100
Be	ICP/OES	-1	-1	-1	-1	-1	-1
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sc	ICP/OES	-1	-1	-1	2	3	3
Sr	ICP/OES	19	35	50	60	35	205
V	ICP/OES	2	3	4	3	5	8
Y	ICP/OES	6	7	4	8	8	10
Ga	XRF	-3	-3	-3	-3	-3	-3
Nb	XRF	-1	-1	-1	-1	-1	-1
Rb	XRF	70	120	70	70	70	60
Zr	XRF	65	95	80	125	120	105
Sm	ICP-MS	-15	-15	-15	-15	-15	-15
Eu	ICP-MS	-1 M	-1 M	-1 M	-1 M	-1 M	-1 M
Gd	ICP-MS	-5	-5	-5	-5	-5	-5

MAJOR OXIDE LISTING

	83RPS-0154	83RPS-0155	83RPS-0156	83RPS-0157	83RPS-0158
SiO2	62.50	56.30	74.50	62.80	73.10
Al2O3	13.10	13.20	12.00	11.00	11.00
Fe2O3	2.23	1.51	0.86	0.43	2.05
FeO	3.78	6.18	1.02	2.47	2.04
MgO	1.28	1.03	0.77	2.73	1.00
CaO	3.65	5.02	2.01	5.56	1.72
Na2O	2.44	2.08	1.52	1.25	0.85
K2O	2.18	2.75	1.89	2.64	2.55
TiO2	1.21	1.34	0.23	0.27	0.16
P2O5	0.29	0.32	0.03	0.02	00.00
MnO	0.10	0.31	0.05	0.14	0.22
CO2	4.68	8.76	2.83	9.16	3.76
S	00.00	0.01	0.02	0.01	00.00
H2O+	1.30	1.20	1.40	1.22	1.49
H2O-	0.06	0.03	0.03	0.04	0.06
LOI	5.80	8.00	4.20	9.50	4.90
TOTAL	98.80	100.00	99.20	99.70	100.00
S.G.	2.79	2.84	2.71	2.76	2.74

TRACE ELEMENT LISTING

METHOD	83RPS-0154	83RPS-0155	83RPS-0156	83RPS-0157	83RPS-0158
Ag AA	-2	-2	-2	-2	-2
As AA	1.5M	15 M	3 M	14 M	12 M
Au AA	4 B	-2 B	-2 B	4 B	7 B
Ba AA	530	690	380	280	460
Co AA	9	15	-5	6	-5
Cr AA	-5	-5	-5	12	-5
Cu AA	48	46	16	10	5
Li AA	14	4	8	6	-3
Ni AA	12	8	-5	10	-5
Pb AA	-10	-10	10	18	-10
Sb AA	1 M	1.3M	1.1M	1.4M	1.1M
Zn AA	49	92	36	44	39
B ICP/OES	100	100	100	100	100
Be ICP/OES	-1	-1	-1	-1	-1
Mo ICP/OES	-10	-10	-10	-10	-10
Sc ICP/OES	11	8	2	4	1
Sr ICP/OES	105	295	70	110	85
V ICP/OES	110	85	4	23	5
Y ICP/OES	19	17	9	9	10
Ga XRF	-3	-3	-3	-3	-3
Nb XRF	8	11	-1	4	1
Rb XRF	50	60	70	50	50
Zr XRF	185	150	140	90	95
Sm ICP-MS	-15	-15	-15	-15	-15
Eu ICP-MS	-1 M	-1 M	-1 M	-1 M	-1 M
Gd ICP-MS	-5	-5	-5	-5	-5

Dy	ICP-MS	7	M	4	M	5	M	7	M	5	M
Yb	ICP-MS	-1	M	-1	M	-1	M	-1	M	-1	M
Ce	ICP-MS	120		115		-35		35		45	
La	ICP-MS	60		65		25		19		30	
Nd	ICP-MS	40		45		-30		-30		-30	

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

59

	MEAN	STD. DEVIATION
SiO2	75.03	5.60
Al2O3	11.95	1.78
Fe2O3	0.72	0.44
FeO	1.34	1.21
MgO	1.06	0.73
CaO	1.59	1.15
Na2O	0.97	1.11
K2O	3.13	0.98
TiO2	0.25	0.23
P2O5	0.03	0.06
MnO	0.06	0.06
CO2	2.20	1.78
S	0.03	0.05
H2O+	1.35	0.45
H2O-	0.08	0.05
LOI	3.53	1.56
TOTAL	99.78	0.56
S.G.	2.72	0.05

TRACE ELEMENT STATISTICS

NO. OF SAMPLES		MEAN	STD. DEVIATION
Ag	59	-2.00	0.00
As	59	4.61	12.26
Au	59	1.22	7.30
Ba	59	479.15	181.54
Co	59	-2.83	5.75
Cr	59	-2.08	7.25
Cu	59	9.66	17.29
Li	59	11.27	5.98
Ni	59	-1.98	7.22
Pb	59	16.92	25.43
Sb	59	1.19	0.78
Zn	59	61.46	59.29
B	59	100.00	0.00
Be	59	-0.37	0.96
Mo	59	-8.90	2.09
Sc	59	2.58	2.31
Sr	59	46.36	45.55
V	59	12.37	21.60
Y	59	12.71	8.13
Ga	59	3.80	6.86
Nb	59	1.14	2.53
Rb	59	74.61	19.45
Zr	59	153.54	53.29
Sm	28	-15.00	0.00
Eu	28	-1.00	0.00
Gd	28	-5.00	0.00
Dy	28	5.54	2.19
Yb	28	-1.00	0.00
Ce	59	66.53	65.57
La	59	11.98	33.16
Nd	59	12.36	38.18

SAGE
MAFIC VOLCANICS; CYCLE I, AREA I

MAJOR OXIDE LISTING

	79RPS-6462	79RPS-6469	79RPS-6470	79RPS-6471	79RPS-6472	79RPS-6473
SiO ₂	48.60	48.62	53.78	49.72	48.40	64.30
Al ₂ O ₃	15.40	14.86	13.15	13.27	15.30	13.10
Fe ₂ O ₃	2.94	3.54	2.32	4.17	4.10	2.01
FeO	8.82	8.82	8.74	11.00	9.15	4.99
MgO	8.07	7.02	7.26	5.10	7.02	2.74
CaO	10.62	10.47	8.22	9.93	8.84	3.53
Na ₂ O	1.88	2.07	3.46	1.72	2.66	4.83
K ₂ O	0.31	0.08	0.09	0.29	0.22	1.46
TiO ₂	0.93	1.19	0.98	1.74	0.98	0.79
P ₂ O ₅	0.70	0.93	0.08	0.21	0.07	0.07
MnO	0.18	0.18	0.18	0.21	0.19	0.09
CO ₂	0.24	0.18	0.35	0.75	0.51	1.69
S	0.15	0.13	0.04	0.24	0.05	0.04
H ₂ O+	1.95	1.89	0.63	0.62	2.55	0.51
H ₂ O-	0.13	0.11	0.11	0.09	0.13	0.08
LOI	2.30	2.10	0.50	0.90	2.80	2.00
TOTAL	100.90	100.00	99.30	99.10	100.10	100.20
S.G.	3.04	3.04	2.95	3.09	2.99	2.80

TRACE ELEMENT LISTING

METHOD	79RPS-6462	79RPS-6469	79RPS-6470	79RPS-6471	79RPS-6472	79RPS-6473
Ag AA	-2	-2	-2	-2	-2	-2
As AA	18 M	17 M	4 M	2 M	1.5M	8 M
Au AA	3 B	-2 B	-2 B	-2 B	5 B	-2 B
Ba AA	170	190	280	130	160	530
Co AA	46	48	45	46	49	20
Cr AA	331	235	232	130	209	32
Cu AA	135	141	73	112	167	48
Li AA	5	4	-3	9	8	6
Ni AA	133	110	77	56	100	22
Pb AA	-10	-10	-10	-10	-10	-10
Sb AA	0.5M	0.7M	0.4M	0.5M	0.5M	0.4M
Zn AA	92	105	93	129	110	50
Mo ICP/OES	-5	-5	-5	-5	-5	-5
Sr ICP/OES	105	100	45	115	105	130
V ICP/OES	255	415	375	420	420	385
Y ICP/OES	20	30	23	50	45	22
Ga XRF	17	21	13	21	17	15
Rb XRF	6	6	7	8	6	41
Zr XRF	30	40	40	95	85	40
Ce ICP-MS	-35	35	39	-35	-35	65
La ICP-MS	-30	30	30	30	-30	38
Nd ICP-MS	-20	20	-20	29	23	30

MAJOR OXIDE LISTING

	79RPS-6482	79RPS-6483	79RPS-6484	79RPS-6485	79RPS-6486	79RPS-6487
SiO2	45.10	45.90	45.50	46.70	44.10	48.50
Al2O3	13.30	13.70	13.60	15.60	13.90	12.10
Fe2O3	1.60	2.20	2.40	4.10	1.60	4.00
FeO	9.15	9.40	10.20	9.32	11.10	10.50
MgO	6.01	7.97	7.76	7.79	7.47	6.27
CaO	8.92	6.80	7.40	9.22	7.31	6.30
Na2O	3.10	2.34	2.00	1.71	2.85	2.23
K2O	00.00	0.01	0.06	0.03	0.01	0.05
TiO2	1.04	1.10	0.95	1.03	0.95	1.27
P2O5	0.06	0.07	0.05	0.07	0.06	0.08
MnO	0.20	0.15	0.21	0.19	0.22	0.16
CO2	7.62	5.59	5.07	0.62	6.30	5.21
S	0.02	0.02	0.02	0.01	0.07	0.02
H2O+	4.65	5.18	4.97	3.60	4.96	4.21
H2O-	0.17	0.21	0.21	0.17	0.18	0.16
LOI	10.30	9.80	9.00	4.20	9.60	8.00
TOTAL	100.90	100.60	100.40	100.10	101.00	101.00
S.G.	2.78	2.79	2.82	3.00	2.81	2.84

TRACE ELEMENT LISTING

METHOD	79RPS-6482	79RPS-6483	79RPS-6484	79RPS-6485	79RPS-6486	79RPS-6487
Ag AA	-2	-2	-2	-2	-2	-2
As AA	-1 M	-1 M	-1 M	2 M	7.5M	-1 M
Au AA	15 B	-2 B	-2 B	20 B	-2 B	-2 B
Ba AA	50	70	40	40	40	40
Co AA	36	42	42	47	60	48
Cr AA	151	164	210	224	210	13
Cu AA	138	63	96	192	185	172
Li AA	13	16	18	14	14	12
Ni AA	68	96	115	126	128	46
Pb AA	-10	-10	-10	-10	-10	-10
Sb AA	0.1M	0.1M	0.3M	0.6M	0.4M	0.2M
Zn AA	100	120	146	118	148	113
Mo ICP/OES	-5	-5	-5	-5	-5	-5
Sr ICP/OES	85	45	70	170	95	65
V ICP/OES	360	360	275	415	350	415
Y ICP/OES	15	12	20	24	21	14
Ga XRF	12	14	13	16	18	19
Rb XRF	5	5	7	6	5	7
Zr XRF	35	35	45	45	45	35
Ce ICP-MS	-35	40	-35	40	65	-35
La ICP-MS	-30	-30	-30	-30	-30	-30
Nd ICP-MS	22	29	26	-20	-20	30

MAJOR OXIDE LISTING

79RPS-6489 79RPS-6490 79RPS-0020 79RPS-0021 79RPS-0022 79RPS-0023

SiO2	48.20	47.80	47.20	46.20	50.10	45.60
Al2O3	15.60	15.10	14.30	14.50	15.10	16.50
Fe2O3	4.95	2.60	2.80	1.70	3.51	3.88
FeO	8.24	10.60	9.15	9.07	8.18	7.94
MgO	7.28	7.11	7.07	4.51	6.42	7.67
CaO	10.50	10.70	8.76	9.04	7.46	10.70
Na2O	2.05	2.31	1.47	1.89	1.03	1.60
K2O	0.44	0.52	00.00	0.17	0.06	00.00
TiO2	0.85	0.84	0.86	0.89	1.09	0.80
P2O5	0.05	0.05	00.00	00.00	0.02	0.01
MnO	0.21	0.21	0.16	0.19	0.15	0.17
CO2	0.18	0.56	4.27	7.04	2.75	0.53
S	0.03	0.10	0.02	0.10	0.06	0.06
H2O+	1.09	0.67	4.55	4.24	4.20	3.11
H2O-	0.11	0.16	0.09	0.09	0.21	0.19
LOI	1.00	1.20	8.30	10.40	6.90	3.90
TOTAL	99.70	99.30	100.70	99.60	100.30	98.80
S.G.	3.08	3.08	2.85	2.81	2.87	3.01

TRACE ELEMENT LISTING

METHOD 79RPS-6489 79RPS-6490 79RPS-0020 79RPS-0021 79RPS-0022 79RPS-0023

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	1.5M	-1 M	155 M	11 M	4.5M	-1 M
Au	AA	4 B	3 B	2 B	-2 B	-2 B	-2 B
Ba	AA	110	160	30	40	40	30
Co	AA	53	53	45	41	39	56
Cr	AA	148	134	276	231	244	121
Cu	AA	103	132	130	45	90	68
Li	AA	14	18	22	27	19	8
Ni	AA	105	108	121	98	97	210
Pb	AA	-10	-10	-10	-10	-10	-10
Sb	AA	0.2M	-0.1M	3.2M	1 M	1.4M	0.4M
Zn	AA	119	111	81	115	130	88
Mo	ICP/OES	-5	-5	-10	-10	-10	-10
Sr	ICP/OES	130	180	65	120	110	90
V	ICP/OES	275	380	240	230	270	210
Y	ICP/OES	20	21	12	9	16	13
Ga	XRF	21	17	13	16	17	17
Rb	XRF	21	18	4	10	10	4
Zr	XRF	24	21	22	11	35	22
Ce	ICP-MS	-35	-35	-35	45	-35	-35
La	ICP-MS	-30	-30	-30	30	-30	-30
Nd	ICP-MS	-20	-20	30	-20	-20	25

MAJOR OXIDE LISTING

79RPS-0024 79RPS-0025 79RPS-0026 79RPS-0027 79RPS-0028 79RPS-0029

SiO2	44.40	45.80	49.40	48.80	49.40	47.40
Al2O3	14.10	17.50	18.10	13.50	13.90	15.00
Fe2O3	1.80	1.38	1.77	3.90	3.20	2.30
FeO	9.32	7.61	5.91	11.70	10.50	9.88
MgO	6.51	4.08	4.42	6.48	8.39	7.12
CaO	8.22	8.18	5.60	6.54	5.22	11.70
Na2O	0.97	3.27	3.81	1.09	2.10	1.38
K2O	0.08	0.60	0.73	00.00	00.00	00.00
TiO2	0.90	1.09	1.23	1.12	0.94	1.03
P2O5	0.01	0.01	0.02	0.03	00.00	0.01
MnO	0.16	0.20	0.14	0.21	0.19	0.18
CO2	6.68	5.92	4.33	0.61	1.05	0.23
S	0.09	0.02	0.21	0.04	0.01	0.14
H2O+	5.12	3.66	3.54	4.38	4.49	2.95
H2O-	0.48	0.15	0.23	0.12	0.30	0.11
LOI	11.00	9.60	7.30	4.20	5.40	3.00
TOTAL	98.80	99.50	99.40	98.50	99.70	98.80
S.G.	2.81	2.79	2.77	2.95	2.87	3.07

TRACE ELEMENT LISTING

METHOD 79RPS-0024 79RPS-0025 79RPS-0026 79RPS-0027 79RPS-0028 79RPS-0029

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	3 M	66 M	19 M	5.5M	1.5M	27 M
Au	AA	-2 B	-2 B	-2 B	7 B	3 B	-2 B
Ba	AA	30	80	140	20	30	30
Co	AA	55	51	101	49	46	38
Cr	AA	226	273	278	27	77	249
Cu	AA	64	16	130	143	68	100
Li	AA	30	21	22	10	13	6
Ni	AA	104	225	215	42	68	96
Pb	AA	-10	-10	-10	-10	-10	-10
Sb	AA	1.1M	0.6M	0.8M	0.7M	0.5M	0.9M
Zn	AA	116	78	75	140	127	101
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sr	ICP/OES	85	55	60	110	45	105
V	ICP/OES	220	250	270	350	300	280
Y	ICP/OES	5	6	7	24	9	15
Ga	XRF	17	17	15	16	14	20
Rb	XRF	9	25	33	6	5	5
Zr	XRF	30	45	50	23	18	35
Ce	ICP-MS	-35	45	-35	-35	-35	40
La	ICP-MS	-30	-30	-30	-30	-30	-30
Nd	ICP-MS	25	-20	25	-20	20	20

MAJOR OXIDE LISTING

	79RPS-0030	79RPS-0031	79RPS-0032	79RPS-0033	79RPS-0034	79RPS-0035
SiO2	50.50	47.50	46.80	47.70	48.30	46.20
Al2O3	14.20	15.00	14.60	14.70	14.00	12.40
Fe2O3	2.50	4.56	3.70	2.30	3.50	1.80
FeO	10.20	6.97	9.48	10.90	10.90	12.80
MgO	6.81	5.65	7.11	6.87	6.07	4.03
CaO	6.47	16.90	11.30	11.90	10.60	8.49
Na2O	4.17	0.17	1.14	0.70	1.55	2.10
K2O	00.00	00.00	00.00	00.00	00.00	0.19
TiO2	0.80	0.70	0.89	0.96	1.25	1.87
P2O5	00.00	00.00	00.00	00.00	0.04	0.13
MnO	0.23	0.20	0.20	0.20	0.21	0.21
CO2	0.18	0.53	0.56	0.18	0.19	5.30
S	0.01	0.01	0.09	0.11	0.07	0.08
Li2O+	2.71	1.64	2.21	2.84	3.00	4.44
H2O-	0.14	0.07	0.07	0.08	0.07	0.08
LOI	2.30	2.20	3.40	2.70	2.70	8.40
TOTAL	98.90	99.90	98.20	98.90	99.30	100.10
S.G.	2.91	3.23	3.05	3.09	3.04	2.84

TRACE ELEMENT LISTING

METHOD	79RPS-0030	79RPS-0031	79RPS-0032	79RPS-0033	79RPS-0034	79RPS-0035
Ag	AA	-2	-2	-2	-2	-2
As	AA	29 M	21 M	36 M	48 M	18 M
Au	AA	-2 B	-2 B	2 B	-2 B	3 B
Ba	AA	20	90	20	30	80
Co	AA	56	36	45	35	43
Cr	AA	189	180	159	162	163
Cu	AA	20	14	108	116	120
Li	AA	5	-3	6	6	5
Ni	AA	72	65	83	84	74
Pb	AA	-10	-10	-10	-10	-10
Sb	AA	0.5M	1.8M	0.8M	0.9M	0.8M
Zn	AA	130	84	102	100	126
Mo	ICP/OES	-10	-10	-10	-10	-10
Sr	ICP/OES	30	240	105	95	120
V	ICP/OES	240	290	290	280	350
Y	ICP/OES	10	16	15	14	19
Ga	XRF	8	18	17	18	21
Rb	XRF	5	-5	5	6	5
Zr	XRF	20	17	25	25	50
Ce	ICP-MS	-35	-35	40	-35	-35
La	ICP-MS	-30	30	-30	-30	-30
Nd	ICP-MS	25	20	20	20	30

MAJOR OXIDE LISTING

79RPS-0036 79RPS-0037 79RPS-0039 79RPS-0040 79RPS-0041 79RPS-0049

SiO ₂	47.50	47.30	49.50	49.80	48.10	42.00
Al ₂ O ₃	14.00	13.20	14.10	14.40	12.10	13.90
Fe ₂ O ₃	3.10	3.29	8.80	6.05	3.30	2.00
FeO	11.10	8.83	5.67	7.70	11.00	11.40
MgO	7.87	6.74	6.21	4.72	6.50	5.49
CaO	7.83	12.40	8.59	7.70	9.44	8.61
Na ₂ O	2.84	1.13	2.97	3.14	1.14	2.80
K ₂ O	00.00	00.00	00.00	0.03	00.00	0.13
TiO ₂	1.27	1.03	0.87	1.21	1.22	1.46
P ₂ O ₅	0.03	0.02	0.02	0.03	00.00	0.10
MnO	0.20	0.19	0.20	0.18	0.21	0.23
CO ₂	0.25	1.55	0.13	1.03	1.53	5.68
S	0.02	0.02	0.01	0.03	0.04	0.01
H ₂ O+	3.07	2.65	2.54	2.77	3.45	4.38
H ₂ O-	0.06	0.03	0.02	0.04	0.12	0.17
LOI	3.00	3.80	2.50	3.60	4.40	9.20
TOTAL	99.10	98.40	99.60	98.80	98.20	98.40
S.G.	2.97	3.04	2.99	2.94	2.98	2.83

TRACE ELEMENT LISTING

METHOD 79RPS-0036 79RPS-0037 79RPS-0039 79RPS-0040 79RPS-0041 79RPS-0049

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	27 M	20 M	-1 M	11 M	19 M	4 M
Au	AA	3 B	-2 B	-2 B	7 B	45 B	-2 B
Ba	AA	20	30	30	20	40	50
Co	AA	46	38	36	37	57	73
Cr	AA	134	121	20	6	15	90
Cu	AA	112	112	20	220	330	14
Li	AA	7	4	6	6	8	13
Ni	AA	72	60	34	18	34	124
Pb	AA	-10	-10	-10	-10	11	-10
Sb	AA	0.4M	0.4M	0.2M	0.5M	0.7M	0.2M
Zn	AA	130	104	112	97	101	178
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sr	ICP/OES	115	140	105	140	120	130
V	ICP/OES	320	300	290	340	370	270
Y	ICP/OES	12	14	17	20	15	15
Ga	XRF	16	22	17	19	17	19
Rb	XRF	6	4	7	6	6	12
Zr	XRF	18	23	19	35	18	45
Ce	ICP-MS	-35	-35	-35	35	-35	95
La	ICP-MS	-30	30	-30	-30	30	35
Nd	ICP-MS	25	-20	-20	20	-20	30

MAJOR OXIDE LISTING

	79RPS-0050	79RPS-0051	79RPS-0052	79RPS-0054	79RPS-0055	79RPS-0056
SiO2	50.70	49.40	49.70	46.50	53.30	49.50
Al2O3	12.80	10.60	13.50	15.00	16.50	14.60
Fe2O3	4.60	7.10	4.35	2.40	1.84	4.20
FeO	9.96	8.91	8.51	8.10	3.73	9.15
MgO	5.92	3.00	6.27	3.97	3.73	3.94
CaO	7.89	6.70	7.10	9.79	9.46	8.11
Na2O	2.83	2.84	2.72	3.25	3.41	1.30
K2O	00.00	00.00	0.02	00.00	00.00	00.00
TiO2	1.26	2.09	1.17	1.18	1.29	2.04
P2O5	0.04	0.16	0.02	0.03	0.64	0.13
MnO	0.21	0.25	0.24	0.31	0.18	0.21
CO2	0.40	4.76	1.18	6.48	2.21	1.15
S	0.17	0.01	0.03	0.20	0.01	0.48
H2O+	2.97	3.07	3.38	3.26	2.38	3.56
H2O-	0.14	0.18	0.19	0.16	0.13	0.12
LOI	2.60	7.10	4.00	8.60	4.30	4.10
TOTAL	99.90	99.10	98.40	100.60	98.80	98.50
S.G.	2.97	2.87	2.91	2.81	2.86	2.95

TRACE ELEMENT LISTING

METHOD	79RPS-0050	79RPS-0051	79RPS-0052	79RPS-0054	79RPS-0055	79RPS-0056
Ag	AA -2	-2	-2	3	-2	-2
As	AA 7 M	1.5M	2 M	25 M	17 M	5.5M
Au	AA 4 B	-2 B	3 B	320 B	14 B	3 B
Ba	AA 40	20	70	30	50	30
Co	AA 55	29	56	56	50	91
Cr	AA 30	-5	40	210	212	111
Cu	AA 220	36	176	114	124	148
Li	AA 3	7	10	16	9	20
Ni	AA 42	-5	39	88	102	120
Pb	AA -10	-10	-10	83	-10	-10
Sb	AA 0.5M	0.5M	0.3M	16.3M	2.4M	6.2M
Zn	AA 106	172	168	146	108	184
Mo	ICP/OES -10	-10	-10	-10	-10	-10
Sr	ICP/OES 110	65	145	110	30	195
V	ICP/OES 370	170	360	340	400	430
Y	ICP/OES 18	25	13	19	13	19
Ga	XRF 13	26	20	16	19	20
Rb	XRF 6	4	8	6	-5	5
Zr	XRF 50	65	21	9	30	35
Ce	ICP-MS 40	55	35	40	-35	55
La	ICP-MS -30	-30	-30	-30	-30	30
Nd	ICP-MS 25	25	-20	-20	-20	20

MAJOR OXIDE LISTING

	79RPS-0072	79RPS-0106	79RPS-0109	81RPS-0137	81RPS-0138	81RPS-0139
SiO ₂	46.70	46.80	48.90	46.00	48.30	52.10
Al ₂ O ₃	7.29	8.33	13.40	12.50	11.70	12.20
Fe ₂ O ₃	2.20	1.60	2.90	1.38	2.60	5.00
FeO	9.56	9.72	9.32	8.25	8.62	8.25
MgO	18.60	17.40	7.92	5.54	4.01	5.61
CaO	9.03	8.73	8.91	7.32	9.46	4.77
Na ₂ O	00.00	0.69	2.87	0.98	1.90	2.66
K ₂ O	00.00	0.03	0.01	0.87	00.00	0.02
TiO ₂	0.59	0.70	1.05	1.42	1.44	1.65
P ₂ O ₅	00.00	00.00	00.00	0.07	0.10	0.02
MnO	0.19	0.19	0.20	0.23	0.18	0.24
CO ₂	0.17	0.09	0.11	11.10	7.84	2.18
S	0.01	00.00	0.07	0.08	0.17	0.07
H ₂ O+	4.34	3.58	2.20	2.85	2.63	3.20
H ₂ O-	0.15	0.11	0.13	0.08	0.09	0.12
LOI	4.60	4.00	2.50	12.20	9.20	5.10
TOTAL	98.80	98.00	98.00	98.70	99.00	98.90
S.G.	2.99	2.99	2.98	2.86	2.80	2.85

TRACE ELEMENT LISTING

METHOD	79RPS-0072	79RPS-0106	79RPS-0109	81RPS-0137	81RPS-0138	81RPS-0139
Ag AA	-2	-2	-2	-2	-2	-2
As AA	27 M	-1 M	1 M	4 M	8 M	9 M
Au AA	3 B	-2 B	2 B	2 B	2 B	3 B
Ba AA	30	20	20	110	20	30
Co AA	95	81	48	47	51	42
Cr AA	2400	1750	302	105	96	111
Cu AA	28	26	120	118	120	114
Li AA	12	14	9	44	43	24
Ni AA	860	605	100	81	53	56
Pb AA	-10	-10	-10	82	-10	-10
Sb AA	0.8M	1.2M	3.2M	1 M	1 M	1 M
Zn AA	103	116	151	128	118	160
Be ICP/OES				1	1	1
Mo ICP/OES	-10	-10	-10	-10	-10	-10
Sc ICP/OES				25	25	23
Sr ICP/OES	8	10	190	175	205	60
V ICP/OES	195	200	300	320	300	370
Y ICP/OES	9	6	16	3	6	22
Ga XRF	11	13	17	14	10	13
Nb XRF				11	10	20
Rb XRF	6	5	6	20	-10	-10
Zr XRF	21	40	18	40	40	25
Ce ICP-MS	-35	-35	35	35	35	35
La ICP-MS	-30	45	-30	-30	-30	-30
Nd ICP-MS	-20	25	25	25	25	25

MAJOR OXIDE LISTING

	81RPS-0140	81RPS-0141	81RPS-0142	81RPS-0143	81RPS-0144	81RPS-0145
SiO ₂	43.70	48.20	49.20	49.20	53.60	45.90
Al ₂ O ₃	13.30	14.20	13.80	14.70	16.00	13.60
Fe ₂ O ₃	2.24	4.71	4.45	3.34	4.50	2.62
FeO	8.25	8.54	7.74	8.40	9.79	9.49
MgO	4.81	7.01	4.82	6.75	7.27	3.95
CaO	10.40	9.64	9.38	9.15	9.92	8.07
Na ₂ O	3.22	1.19	0.91	1.87	1.42	1.26
K ₂ O	0.03	0.20	0.61	0.05	0.16	1.09
TiO ₂	1.49	1.30	1.15	1.21	1.26	1.73
P ₂ O ₅	0.10	0.06	0.07	0.08	0.05	0.07
MnO	0.33	0.19	0.28	0.21	0.24	0.33
CO ₂	7.72	0.15	3.75	0.52	0.88	7.74
S	0.01	0.07	0.10	0.08	0.02	0.06
H ₂ O+	3.28	3.27	3.30	3.27	3.63	3.39
H ₂ O-	0.12	0.09	0.12	0.09	0.15	0.17
LOI	10.50	2.70	6.70	3.10	3.70	9.80
TOTAL	99.00	98.90	100.00	98.90	99.00	99.50
S.G.	2.80	3.01	2.92	2.97	3.03	2.76

TRACE ELEMENT LISTING

METHOD	81RPS-0140	81RPS-0141	81RPS-0142	81RPS-0143	81RPS-0144	81RPS-0145
Ag AA	-2	-2	-2	-2	-2	-2
As AA	9 M	8 M	-1 M	1.5M	8 M	31 M
Au AA	3 B	2 B	-2 B	3 B	-2 B	-2 B
Ba AA	30	80	150	40	140	130
Co AA	35	50	43	48	47	38
Cr AA	118	191	130	135	142	129
Cu AA	112	158	130	150	50	158
Li AA	16	14	16	8	11	24
Ni AA	49	92	75	85	84	48
Pb AA	-10	-10	13	105	44	90
Sb AA	0.4M	0.8M	1.4M	19.8M	19.8M	19.8M
Zn AA	200	134	119	128	141	170
Be ICP/OES	1	1	1	1	1	1
Mo ICP/OES	-10	-10	-10	-10	-10	-10
Sc ICP/OES	25	35	25	25	30	35
Sr ICP/OES	45	175	130	85	155	35
V ICP/OES	320	340	310	330	330	360
Y ICP/OES	30	18	17	15	20	9
Ga XRF	18	21	22	19	14	17
Nb XRF	17	23	15	15	19	20
Rb XRF	-10	-10	20	-10	-10	30
Zr XRF	60	16	11	21	16	60
Ce ICP-MS	35	35	35	35	35	35
La ICP-MS	-30	-30	-30	-30	-30	-30
Nd ICP-MS	25	25	25	25	25	25

MAJOR OXIDE LISTING

	81RPS-0146	81RPS-0147	81RPS-0148	81RPS-0149	81RPS-0150	81RPS-0151
SiO2	48.60	45.50	50.20	49.50	48.90	43.20
Al2O3	12.30	14.40	15.10	15.40	13.40	11.30
Fe2O3	1.37	2.77	3.21	4.56	5.51	5.57
FeO	8.40	8.25	7.23	8.91	7.67	12.30
MgO	3.71	5.34	4.80	5.49	7.06	5.50
CaO	7.88	9.78	6.99	8.67	10.20	7.62
Na2O	0.68	2.02	3.52	1.02	0.91	0.97
K2O	1.85	0.01	0.03	0.12	0.18	0.47
TiO2	1.49	1.22	1.28	1.34	1.12	2.45
P2O5	0.09	0.08	00.00	0.08	0.13	0.15
MnO	0.18	0.30	0.28	0.26	0.19	0.24
CO2	9.07	5.27	3.36	0.56	0.61	6.17
S	0.11	0.03	0.03	0.05	0.17	0.10
H2O+	2.94	3.37	3.11	3.45	3.05	3.67
H2O-	0.11	0.11	0.14	0.11	0.15	0.21
LOI	10.80	7.80	6.70	3.50	3.50	9.40
TOTAL	98.80	98.40	99.30	99.70	99.30	100.00
S.G.	2.78	2.81	2.79	2.94	2.98	2.86

TRACE ELEMENT LISTING

METHOD	81RPS-0146	81RPS-0147	81RPS-0148	81RPS-0149	81RPS-0150	81RPS-0151
Ag AA	-2	-2	-2	2	-2	-2
As AA	48 M	1.5M	8 M	14 M	1.5M	-1.5M
Au AA	-2 B	-2 B	-2 B	-2 B	-2 B	-2 B
Ba AA	110	30	20	60	60	110
Co AA	37	48	47	48	43	43
Cr AA	112	144	138	153	112	6
Cu AA	123	160	141	158	132	225
Li AA	17	11	16	10	10	16
Ni AA	48	83	79	84	68	21
Pb AA	48	35	40	45	42	51
Sb AA	4.2M	3 M	3 M	3 M	5.1M	5.1M
Zn AA	142	150	133	146	111	124
Be ICP/OES	1	1	1	1	1	2
Mo ICP/OES	-10	-10	-10	-10	-10	-10
Sc ICP/OES	30	35	25	13	30	40
Sr ICP/OES	35	70	60	85	160	90
V ICP/OES	340	330	330	360	340	600
Y ICP/OES	5	23	14	8	17	11
Ga XRF	14	19	7	6	14	13
Nb XRF	16	20	16	14	16	40
Rb XRF	40	-10	-10	-10	-10	10
Zr XRF	45	30	14	-1	25	45
Ce ICP-MS	35	35	35	35	35	35
La ICP-MS	-30	-30	-30	-30	-30	-30
Nd ICP-MS	25	25	25	25	25	25

MAJOR OXIDE LISTING

81RPS-0152 81RPS-0153 81RPS-0155

SiO2	51.60	50.50	49.40
Al2O3	12.80	13.10	13.70
Fe2O3	6.00	5.06	4.16
FeO	8.84	9.13	8.33
MgO	5.42	5.98	7.43
CaO	7.61	9.92	9.65
Na2O	0.97	1.01	1.35
K2O	0.39	0.05	0.19
TiO2	1.72	1.27	0.92
P2O5	0.15	0.13	0.11
MnO	0.18	0.19	0.20
CO2	0.73	0.60	0.31
S	0.07	0.08	0.04
H2O+	2.94	2.73	3.07
H2O-	0.14	0.13	0.13
LOI	3.50	3.00	3.20
TOTAL	99.60	99.90	99.00
S.G.	2.93	2.98	3.01

TRACE ELEMENT LISTING

METHOD 81RPS-0152 81RPS-0153 81RPS-0155

Ag	AA	-2	-2	-2
As	AA	17 M	30 M	3.5M
Au	AA	3 B	-2 B	20 B
Ba	AA	160	40	80
Co	AA	40	48	47
Cr	AA	23	93	235
Cu	AA	167	144	162
Li	AA	12	9	10
Ni	AA	20	47	90
Pb	AA	25	17	26
Sb	AA	7.7M	5.5M	2.5M
Zn	AA	129	160	119
Be	ICP/OES	2	2	1
Mo	ICP/OES	-10	-10	-10
Sc	ICP/OES	30	30	20
Sr	ICP/OES	160	155	115
V	ICP/OES	410	340	330
Y	ICP/OES	35	20	12
Ga	XRF	22	22	20
Nb	XRF	25	19	12
Rb	XRF	10	-10	-10
Zr	XRF	24	23	8
Ce	ICP-MS	35	35	35
La	ICP-MS	-30	-30	-30
Nd	ICP-MS	25	25	25

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

63

	MEAN	STD. DEVIATION
SiO ₂	48.35	3.13
Al ₂ O ₃	13.85	1.77
Fe ₂ O ₃	3.40	1.50
FeO	9.04	1.62
MgO	6.39	2.53
CaO	8.77	2.01
Na ₂ O	1.99	1.03
K ₂ O	0.19	0.36
TiO ₂	1.19	0.35
P ₂ O ₅	0.09	0.16
MnO	0.21	0.04
CO ₂	2.71	2.91
S	0.07	0.08
H ₂ O+	3.16	1.08
H ₂ O-	0.14	0.07
LOI	5.37	3.15
TOTAL	99.37	0.78
S.G.	2.92	0.11

TRACE ELEMENT STATISTICS

	NO. OF SAMPLES	MEAN	STD. DEVIATION
Ag	63	-1.86	0.80
As	63	13.88	22.74
Au	63	7.17	40.74
Ba	63	73.81	79.67
Co	63	48.46	14.14
Cr	63	205.52	355.58
Cu	63	116.54	60.17
Li	63	12.83	8.61
Ni	63	102.11	125.06
Pb	63	4.56	28.81
Sb	63	2.51	4.62
Zn	63	123.49	28.24
Be	18	1.17	0.38
Mo	63	-8.89	2.10
Sc	18	27.83	6.32
Sr	63	103.62	50.38
V	63	324.68	70.59
Y	63	17.11	8.82
Ga	63	16.67	3.88
Nb	18	18.22	6.72
Rb	63	5.98	11.56
Zr	63	32.57	17.64
Ce	63	9.59	38.79
La	63	-18.13	24.75
Nd	63	12.76	20.23

□□ CAGE□ □ □ □
MABIC VODCANICC; CYC@E□I

ARAAI

□ □ □ □ □ □

MAJOR OHIDE LISTIFG

□
 □ '9RPS-65067)R0S-650' □9RPS-65 8 7□RPS-6009 79RPC-0522 7!R0S-6023
 □ ClO2 □ □47.00 51.2 □ 44.90 □ 46.50 □ □ 45.10 □ 47"9□
 Al"O□ □ 13.10 □ 1461□ 1".00□ □ 12.3□ □11.20□ □ 14.90□
 Fe2O3 □.50 □ □3.40 □ □.80 □ □1.9 □ 4.68 □ 561
 FeG □ □ □ . 0 □ 7.74 □ □10.60 □ 9.1□ □ (.57
 □7.6%□ Ego □ %11□ □ □7.0□ □ .06□ □ □6.00 □ □.01 □
 6.20
 CaO □ □ □ '.09 □1.0 □ 8.62□ □ 9.1 □ □ 1.01 □0.7□□
 Na2O □ □ □ #. 0□ 1.76 □ 3.15 2

72 □ □ 1.64

□1.80□ C20

□

!. 2

0.01

□ 0□. 0□

□0

0 0 0 0.04 0 0 0 01
TiO2 0 0 0 !.16

0

95 □ !.77□ 009# .94 □ □0.89□ @2G5□ □ □ .08□
0008 0.10 0.06 . 5 000□
MnG □ 0.18□ 0029 □ 0."6□ 0

21
7674

□ .21 □
0.21□

0.19□ CO2
0

□ □ □ □ 5.05□

001□

□.39 □ □

7□

C

820+□

□

□

□

.92

□

2.11

0.02

1

□

□

0. 4□

□

0002 □

□

0.04

040)

8\$ □ □ 3.60 □ 2

9!
H2O-

□ 3.04
□

□ □ 2&84
□ □ .02

□0

9

1# □. 9 □ 0.14 □ □ 0.08 □ 0022
LOI □ □ □ □ 7.40 □ 2.00 9. 00 !0

5 □ □ 3.00 □ □ 0347□
DODAL □ !00.70□ □ 19.6 □ 91.00 □9

70 9(.00 9.3

TRACE ELEMEND LICING MET@OD 7RPS-606 79RPC-4507 7RPS-6508 #9BPS-65 9079R@S%622 '9BPS-65"30

Ag AA - !2 -2 -2
As AA 1 M 10 M !1 A -! M -1 M 12 M
AE AA 3 B 2 B 6 B 7 B
Ba AA 30 40 50 30 50 60
Cg AA 50 45 4 42 4 5
Cr AA 114 02 #4 00(218 11
Cu AA !73 70 !2 2 !1# 102
Li AA !4 & 9 12 8 (
Ni AA 7 (6 39 75 11 108
@b AA -00 -1 -!0 -1 -0 -10
SB AA 0.2M 009M 0.0M 063M .0M
06M Zn AA 86 9# 105 10 101
Mo ICP/OES - -5 -5 -5 -15
Cr ICP/GES 0 14 100 150 160 180
V ICP/OES 90 300 90 2(5 405 40
I ICP/OEC 24 2% 18 10 23 23
Ga XBF 1 5 17 13
Bb PRF 0 & 7 7
Zr XRF 21 8 50 4 18 11
Ce ACP-MS -#5 35 45 40 42 42
La ICP-MC -30 -30 %3 -00 -30 -30
Nd ICE-MS 2 2% 5 28 28 28

□

MAJOR OHIDE□LIS@IFG

□

□ □ 79RPS-"524 79RPS6525 '9BPC-□5□6□71R@S%6□27 #9BPS-□5□8 7 RPS□6521

S102□ □ □ □ 4□.50 □ \$6.0 □ 48.10 46"8□ □ 4□.20□ □ □8

5□

Al²O₃□

Fe₂O₃

□ □ 14.□□

□ 3.10□

11"8

4

1□."0□

12.2

1□.40

□ 15.50□

x

00 □ □ '.03 □ □4"3 □ 0.01□ 3"05
FeG □ □ □1□.0 □ 10.4 □ □ '.09 9"1□ 8.)0□ □ 8

2\$

MgO □
CaO □

□

8.00□

□4.16

□.5

4□51

□ 4.17

6□57□

□

6.16

□

8.5' □

□ 8.05□

□7

2(□
Fa□□

.□8

7&4□

" .#0□

2□5"

".53

□3.68

□ □ □.□3

4

11□ K2O □ □ □.21 0.3 □ 0.16□ □ □0.70 0.11□
0□08
TiO2 □ □.45□ □ 1

77 □ 1.12□ 105□ □ 2.15 1.04
#2G5 □ 0. 9□ 0

13 □ 0.06 □ 0.11 □ 0.14 □ □ □0

01 □ MnC

□

□ 0.18

□ 0

21 □ □ 0.22

0

2!

0.18□

0.11□ CO2

□

3.□2

6

80 □ □.□1□ □5□89 □ 1.)5 □ 145□
S □ 0.08 □ 0□11 □ 0.□1 □ □0.0□ □ .12□ □ 0

0□

H2O+□ □

□

4.25

□

3.20

".46

□

3"0□

□.84

□

2&6 □

H2O-

□

.30□

□

0.2□

□

.70□ □

□0.22 □

0.□8

0&2!

LOI □

□

□.80

□

9.1

□

4.00□ □

7"60

□

□.40

□

4

00
 @ODAD □ □ !0 .□0 1□0.20 9).#0 99.8 9□.40 □ 99.1 □

DRACE ELEMENT LISTINC

□METHOD 7 RPS!6#2\$ 79BPC-6525□7)RPS#6□26 79RPS-65□7 79R0S-6!2(79BPS-
 &5□9

AG	AA	□	-2	□	-2□	□	-"	□	%2□	□-2	2
As	□	AA	□	17	M	□	-□	□M	□	2	E
□Au	AA	□	2	B		□	□-2	□B	□	2□	B
Ba	AA	□	4	0□	!50	□	0□		□70	□	70
Co	□AA	□	□4(	□	□1	□	44	□	□7	4□	□
□□ Cr	□ AA		□1	5	□	□3(	□	81	□	□80	□
□										□	38□
□Ce	□AA	□	□	!19	□	□1□3□	□	8%	□	□	□3□
Li	□	AA	□	□3	□	9	□	8	□	1	□
Ni	□	□AA	□	58	□	"5	□	56		#4□	□21
Pb	AA	□	□-!0□	□	-1	□	□-□0	□	-10	-!0	□
Sb	□	□AA		0.#M□		0					□1

2M

□ .7M

0.1M

□

0.(M□□□0

3E									
Jn	AA	124	126	105	12	118	10		
MG	ICP/OAS	-8	5	~!	5	-5	-5		
Sr	ICP/OES	!0	55	2 5	60	1'00	75		
V	ICP/OES	\$90	5!0	5%	515	48	305		
Y	ICP/CES	30	3	30	3	40	23		
GA	XRF	1\$	8	17	20	2	12		
Rb	HRF	50	1	1	2%	1	'		
Zr	XBF	2"	0	)	65	3	21		
Ce	ACP-MS	-85	4(	-5	3%	6	-35		
La	ICP-MS	-30	-80	!30	-80	30	-30		
Nd	ACE-ES	22	2	26	3	31	-2		

MAJOR O@IDE LISDING

9RPS-6530 79R@S-6#3 79BPC-532 7)R@S6#3# 9RPS-6534 7 RPS-

6!3

SIG2

47."0 46.5 4.20 52

20

04 .000

01

0

Al ₂ O ₃	□	14.60	□	□4.2□	14.40	!3&4	□13.60	□	!2"8□
Fe ₂ O ₃	□	□ 3.37	□	4.4	□.18	□ 2.55	□ 3.60	□ □	□1.99□
FeO	□	□ □.32	□	10.2 □	7.40 □	8.1% □	□ □.02	□	8.6□
AgO	□	□	□	5.59	□ □8&1□	□.□8□ □ □	6.6□	□.□4	□ 6.87
CaO	□	□	□	1□.80	7"9□	1□.30	8□1)	1.97	□ 7"7□□
Na ₂ O□	□	□	□	□.□9	□ 1.87 □ □	!..□5	4&00	!..□8	3.11
K ₂ C	□	□	□	0.□2	0"06 □	□.01□	□ 0		

01	□	□	0.05	□	□	0.04	□	TiO2		0.1	□	1.04	□	0.99	□
0.9'	□		1.04	□	□	0.94	□	P2O5	□	.06		0.0	□	0.7	□
0.04	□	□	0.7	□	□	0.04	□	MnO	□	0.20		0.23	□	.3	□
0.2"	□		.01		□	0.19									
CO2	□		□	□	3.02	□	□	0.3	□	.05		0.6	□	0.60	□
C	□	□	□	□	1.00	□	□	0.01	□	0.11	□	0.10	□	.05	□
20+	□		□	□	21.80	□	□	3.5	□	3.03		1			□

70	0	0.05	0.26						
020-		0	0.17	00.20	0	.260	00.15	0 0.20	0.11
LOI	0		0.00	3.8		1.80	2.5	0 0.00	04.60
DODAL	0		000.10	18.8	0	100.10	09		

0 99.60 844

□

TRACE ELEMENT DISTING

□ □ METHO# 7RPS-6530 79BPC-651 7RPS-632 79BPC-53 7RPS-634 79BPC-655

□

Ag	AA	-□	□	-2	□	-2	□	-2	□	-□	□	-2
As	AA	□	1□ M	□	□ M	□	4 M	□	16 M	□	28 A	-2."M
AE	AA	□	" B	□	2 B	□	□	□	3 B	□	-2 B	□
Ba	AA	□	90	□	5	□	□	4	□	□	□	5
Cg	AA	□	□	□	43	□	46	□	48	□	5	□
Cr	AA	□	208	□	"4	□	□	115	□	□	126	□
Cu	AA	□	!45	□	10	□	□	8"	□	124	□	34
Li	AA	□	6	□	1	□	□	□	□	7	□	□
NA	AA	□	118	□	132	□	51	□	□	6	□	60
□	Ab	AA	□	-!0	□	10	□	-!0	□	-10	□	-10
□	SB	AA	□	0.6M	□	0.4E	□	1.□	□	0.5M	□	□
Bn	AA	□	12	□	□	□	□	3	□	9	□	112
MG	ICP/OES	□	-5	□	□	-5	□	-8	□	-5	□	□
□	Sr	ICP/CEC	15	□	□	80	□	145	□	11	□	15
□	V	ICP/OES	□	38	□	395	□	42	□	375	□	2
A	ICP/OES	□	22	□	□	2	□	□	5	□	23	□
Ga	XRF	□	14	□	□	15	□	□	□	14	□	17
Rb	ERF	□	7	□	□	□	□	6	□	5	□	8
ZB	XBFI	□	0	□	□	20	□	□	8	□	4	□
Ce	ICP-MS	□	\$9	□	-3	□	□	-35	□	□	39	□
LA	ICP-MC	□	-30	□	-80	□	□	83	□	-□	□	30
Nd	ACP-MS	□	-0	□	20	□	□	3	□	30	□	8

□

MAJGR OPIDE LASDING□

□

□	□	□9RPC-□536	71R□S6537	□9RPS-6538	7	RPS-6□3□	□9RPC-□5□0□7	R□S-
6□4□□								
SiO2□	□	50. 0	□ 51.70	□	51.□0	□	\$7□5□	□4□. "0
Al2O3		□13. (0	□ 13□6	□	□14.50	□	!4.8□	15. !0

49.40

14

1

FeO3 □ □
FeG □

□ 5.70 □ 2.3 □ □
□ .82 □ 8.57

□ .41
6.04

4040 □ 4.61
848 □ 7.82

3.2!
6

41

MgG □ □

□

6.39

6.7"

4.05 □

7.2□

□.25

6

8!

CaO	□	□ □	1.'5	□	7482	□	9.57	□	11.0□	□	1□.30□ □	10.4□
Na ⁺ O□		□ □	0.10		149□		"□0	□	1			

[illegible]

80 0

" .00

04

9.40 ☐ 9(.!0☐

@RACE ELEMENT LISTING

□ METHOD 71RPS-6!3□ 79RPS-65#7□79RPS-653(79RPC-65□9□7)R0S-6540 #9BPS-65 1

Ag	AA			-2		-2			-2		!2		-"			2		
As	AA			4	E		4	M		1	A	7	M		2.6A		1"	M
Au	AA			6	B		-2	B				3	B				14	B
Ba	AA			120			4			00		50			50		50	
CO	AA			43			\$4			43		6			5!		4	
Cr	AA			6			00			100		85			2(3		9	
Ce	AA			9			121			11		16			10		300	
Di	AA			12			1"			7		10			8			
Ni	AA			43			8			7		10			120		83	
Pb	AA			-!0			10			-00		-10			-!0		-10	
Sb	AA					0.6M			0*5E					1.1E				
2.3E	Zn	AA				101			10			2			103		103	
Mc	ICP/OES			-8			-5			-		-5			-		-5	
Sr	AC@/OEC			155			10			100		!4			1#5		11	
V	ICP/OES			45			425			39		305			6		305	
A	IC@/OEC			3			27			23		24			50		2"	
Ga	XB			18			!4					0					20	
Rb	RF			30								5						
ZB	XB			16			!5			2		6			2		24	
Ce	IC@-MS			60			30			-35		-3			-#5		-3	
LA	ICP-MC			3			-00			-30		-30			-30		-00	
Nd	ICP-MS			0			-20			-"00		2			"50		20	

□
□
□

MAJOR OXIDE LISTING

□	□	□	79BPC-□5 2 7	□RPS-6543	79BPC-65 4 7	RES%6□46	79BPC-□5\$8□7	RPS□6□5
□	ClO2	□	4□.40	5□20	□ 44.)0□	□ □ 8.10	□ 48.60□	□ 47□20
□	Al2O3	□	1□.40	12□80	□1□.50	□2.6	□ 15. 0□	□ □ 6.30
□	Fe2O3	□	□ 4.70	□2.50	5.00□	□ 4		

8

4			4.02		405							
FeO					7.44	9032	9.10	8090	1.19	7.4		
MgG				7.07		6020	4.18	03				

14 □ □ 6.61

7

100 CaO

□

□1 .40 □

9.08

□

8.13

□

7

73 □ □12.00□ 10

40

Na	□	1.17	1.9	2.56	388	0.09	1.3
K2O	□	0.07	0"0	00. 0	00&00	0.03	0000
D102	□	0.03	0				

8□	1.(3	□	□1.6(	□	□ 0. 6	□ □	049□				
02G5□			□ 0.07	□	□0□05	□ □	.13	0.1□	□. 6	□0.07	
EnO	□ □	□	.18	□	0*2□	□.27	□ 0425	□ .□0	□	0.10□	
CO2 □	□ □	□	.13	□	□6.32	6.74	642!	.□0		0	

1□

S	□	□	0.11	□0.01	□□	□.01	□	0*0□	□	□□.03	□	□□400
020+			□.□3□	□	3□90	□.\$1	□	3.16	□	2.36		361□
H2O-	□	□	□	□	.20□	□	□0.28	□	.22□	□	0	

2(0.00 0.25 DOA 0.90 10.30 0.10 8*1
 2.00 3.20
 TOTAL 90.00 98.9 91.00 10044 9 .)0 99.4

DRACA ELEMENT @ICTING
 7 RES-648 79RPS-6500 MET@OD 79RES6!4 79BPS-5 307R0S654 9BPS-6546

AG	AA	-2	-2	-*	-2	-2	-2
As	AA	22 E	-1 M	2 M	CM	6.5M	3 CM
AE	AA	-B	2 B	-2 B	2 B	3 B	2 B
Ba	AA	10	80	10	50	10	80
Co	AA	4	8	3	4	3	4
Cr	AA	273	144	15	80	220	211
CE	AA	10	93		0	0	19
Li	AA	10	1*	0		5	4
Ni	AA	1	18	3	7	16	16
@b	AA	-00	11	-!0	10	-00	-10
Sb	AA	1.1M	02M	0.1M	0		

3M	0.1M	0.9M	Jn	AA	106	130	146	108
100	!	0						
Mo	ICP/OES	-!	-5	-!	5	-	5	
Cr	ICP/OES	1!5	8	5	1	110	!	3
V	ICP/OES	55	3 5	!2	400	70	30	
I	ACP/OEC	25	21	40	14	!4	26	
Ga	XRF	2	!	1	17	15	15	
Rb	HRF	7	(	5	6	7		
Zb	XRF	2	*1	8	5	45	23	
Ce	ICP-MS	-35	35	39	3	00	35	
LA	ICP-MC	30	9	30	35	-3	-0	
Nd	ICP-MS	0	2	22	2	20	21	

□

□

MAJOR O&IDE LIS&ING

□	□ □ □9BPC-6551 7	RPS!6%5□ #9BPC-6553 81R080282	1RPC-□203□01R0S-
0□84□			
C1G2 □	□ 4\$.40□	43.9 □	5\$.00 □ □245□
A1□03 □	14.00	!2"8□	1\$.50□ □3

0	□	15.10	□	□468					
Fe2O3	□		□	□.20□	□3.35	□.□0	2□8		4.50
4.37									
FeO	□		□	9."5□	8□15	□10.10	□9"7□	□	8.43□ □□8.4
EgG	□			7. 0 □	6				

68

□ 6.53 □

6.2□

5.49□

6

54

CaG

□

□

□ 8.19

□

1041□ □

□.99

6

54	□1	.(0	□	!0□70									
Ba□O		□		1.'1□	1.7□	□	2.60	□	□261□	□	0.88	□	0.7□
K2G	□	□		0 .□0	□0.0□	□	0. 1□	□	0.1□		□.01	□	0401
@102	□	□		□.08□ □	0.8□		□.□1	□	1.15		□ 1.13	□	140)
@2G5	□		□ □	0.07	□ 0*07 □		□.11	□	0.0□		□.01□ □		0.0□
MnC □			□ □	0.19	□ 0*2\$ □ □ □		.12	□ □	0.2□		□.18		0

8

1

CO

□

□

□

4.4

□

7"6

□

□.66

1

89 □ ".□2 □ □1&6)
 C □ □ □. 3 □ 0.02 □ 0.04 □ □0&0□ □ 0.08 □ 0"0□
 H2G+ □ □ □.19 □ 4.5□ □ 4.14 □ 3"3□ □ .49 □ 3&56
 @20- □ □ □.80 □ 0.2□ □ □.00 □ 0.05 □ □.15 □ 0&0□
 LOI □ □ 8. 0 □ □1.60 □ 4.50 □ 4.4□ □ □.30□ □ 5"0
 @ODAD □ □ 100.70 □ 1 0.30 □ 10 .50 □ 99.8 □ 9□.80 □ 99"7□

□□ DRACE ELEMEN@ DICTANG□

□MET@OD □79RPS-655! □9RPS-"5□2 7 RPS□655□ (1BPS- 2□2□8!R@S□0283 01RPS-
 □2□4□

Ag □ AA □ -" □2 □ -" □ □ □ □
 As AA□ □ □ -1 E □ □.5M □ 1 E □ □ □41 M
 AE AA □ □ 4 B □ -2 B □ -2 □B □ 2 B □ -" □B □ 12 B
 Ba□ AA □ □ 80□ □ 60 □ 80□ □ 60 □ 80 □ 60
 CO AA □ □ 4□ □ □1 □ 40 □ □ 41 □ 4□ □ □40 □
 Cr AA □ □ 227 □ 94 □ 188 □ 108 □ 234□ □ 22 □
 Cu □ AA □ □ □9□ □ □92 □ □ 8□ □ 0□ □ 13& □ 12 □
 Li AA □ □ 08 □ 12 □ 15 □ □16 □ □ □0 □ □0 □
 Na □ AA □ □ 122 □ "5□ □ 52 □ "7□ □ □11 □ 104□ □
 Pb□ AA□ □ □ □-□0□ □ 1□ □ □-10□ □ □ -10 □ □ □ -□0 □ 11
 Sb AA □ □ 0. M□ □ 0□3M □ 0.□M □ □ □ □ □2.2E
 Rn□ AA□ □ □ □116 □ 9□ □ □116 □ □11& □ □ 118 □ 10□
 BE □ICP□OES □ □ □ □ □ □ □1□ □ □! □ □ 1
 Eo IC@/OES □5□ □ □-□ □ □-5 □ □ □ □1□ □ -10 □ □ □ -1□
 Sc ICP/OAS □ □ □ □ □ □ □0□ □ 40 □ □40
 Cr□ ICP/OEC □ □ □5□ □ □85 □ □"5 □ □ 55 □ 1 5□ □ 150
 V □ICP#OAS□ 400 □ 405□ □ 39□ □ □ □2#0□ □ "5□ □ □245 □
 Y ACP/GEC 24 □ 21 □ 10 □ □ □19 □ □16 □ □17 □
 □Ga □ XBF□ □12 □ □ □ 18 □ □ □ □ □
 Bb□ XRF □ □ □ □ □ □ □ □ □8 □ 1 □
 □Rb XRF □ 4 □ □ □ 6 □ □-□0 □ 10 □ -10 □
 Jr HRF □ □ □ 14 □ □ 1□ □ □ 60 □ □1□ □ 14 □ □ 1□ □
 □Ce ICP-MS □ -3% □ -35 □ □-3% □ □ -□5 □ □ □-3! □ □ □-□5 □
 Da□ ACP-AS □-30 □ 130 □ □-□0 □ □ □30 □ □-30 □ □ □30 □
 □Nd □ICP!MC □ -20 □ □ -□0 □ 2□ □ □□6□ □ □2& □ □ □6

EAJOB GXIDE HISTANG

□ 81R0S-028% □1BPC- 2□6 81RPS-0"8□ 81RPC-02)3□81R0S-0□9\$ □4RPC-□002□

□SiO2	□ □	□ 48.50	45.50	□	\$9&1□	□ 4'.20□	□9.70	□	4□.30
AD2O3		□ 14"8□	□ 1□.70□	□	13"1□ □	1□.70	12□4□	□	1□.90□
□Fe2O3		□ 5.2□	□. "0	□	3.63	□ □.50	2&1□		□.□6
FEO	□ □	□ □7.45 □	1.□8□		6"79	□. \$9	□	8.98	□.93□
MgO	□	□ 6.0□	□ □.□5		□6				

8"	□	7.03	□	8.1!	□	□	6.73□						
CaO	□		□	0.80	□	(.40□	10.20 □	(.07 □	□7□99	□	.□4		
Na2G		□	□	141□	□	2.□0	□2"8!	"□3	□3.2!		2.16□		
K2O	□		□	0.05	□	□.□1	□ □0.03	□ □	.02□	0□0□	.□9		
TaO□		□	□	1.14	□	1. 9□	1□05	1.□0	□1"1□	□	□.70		
□P"O□	□ □		□	0.0!	□	□.01	0.02	.01□	0				

01 □ □ 0 . □ 0 □
MnO □ □ □ 0.1 □ □ . 09 □ 0

2	0.18	0.11	0.17				
CO2	1.21	0.10	2.56	0.63	1.67	0.33	
SO2	0.10	0.5	0.02	0.09	0.01	0.03	
H2O	2.56	0.72	2.70	0.9	2.8	0.0	
H2O	0.00	0.12	0.10	0.2	0.00	0.12	
LOI	4.1	7.90	4.30	0.60	4.00	1.00	
TOTAL	99.2	100.20	19.1	99.40	8.40		
9.40							

TBACE EDEMEBT LASTING

EETHOD 81BPC-0285 8!RPS008 01BPS- 287 8!RPS!0*93 1RPC-02)4 8\$R0S-0002									
Ag	AA	0	0	0	0	-2	0	-2	0
Ac	AA	0	05	M	29	E	0	08	M
Au	AA	0	0	0	0	0	0	0	0
Ba	AA	0	070	0	00	0	0	60	60
Co	AA	0	08	0	032	0	0	04	0
Cr	AA	0	22	0	210	0	0	11	0
Cu	AA	0	16	0	07	0	0	021	0
La	AA	0	0	0	10	0	0	08	0
Ni	AA	0	107	0	105	0	0	58	0
Pb	AA	0	3	0	12	0	0	2	0
Cb	AA	0	03.6A	0	2.6M	0	0	4.5M	0
Zn	AA	0	020	0	1*4	0	0	09	0
Be	IC@/OEC	1	0	1	0	1	0	0	1
MG	ICP'OES	0	01	0	-00	0	0	01	0
Cc	IC@/OEC	0	05	0	4	0	0	45	0
Sr	ICP/OES	0	155	0	00	0	0	70	0
V	ACP/OES	0	250	0	250	0	0	250	0
Y	ICP#OES	0	2	0	17	0	0	24	0
Ga	0RF	0	0	0	0	0	0	13	0
Nb	XBF	0	9	0	9	0	0	16	0
Rb	PRF	0	-00	0	-1	0	0	10	0
ZB	XBF	0	16	0	6	0	0	00	0
Ce	AC@-MS	0	-35	0	35	0	0	-35	0
La	ICP-MS	0	-3	0	-00	0	0	-30	0
Nd	IC@-ES	0	26	0	2	0	0	26	0

□

MAJOR OXIDE LADING

	□	□	□	1RPS-02□7□81R8S□0298	81RPS- 299 8!R8S!0#00	1RPC-03 1 8!R8S□0#0"□
SiO2	□	□	45.80	□	48.7□	□ □4□.00□ □ 47*8□ □ 4□.50 43.4□
Al2O3	□	□	1□.90	□	!3.6□	1□.10 □ 13.40 □13.70 □ □648□
Fe*O□	□	□	□ □.11	4□4□	□.07□	□3.8 ' .26 □ □5□3
FeO	□	□	7.□1	8		

55 □ (. '6□ 9.6 □ □ 6.49 □9.2□
MgO □ □ □ 5.19□ □ 6

45 ".00 06"95 0 4.)70 5"100 CaO 0 014.00
09.70 0 0.320 6

15	□ □ 11.50 □	5616 □ Na2O □	□	□	1.2 □	2607 □	2.87 □	
2018	1.12	□ 4.57 □ K2O	□	□ □	.06 □	001 □	□ 0.09 □ □	
0604	.06	0.06						
DI02		□ □ .14 □	1.27 □	□	1.87 □	□	1034 □ □	□ .06 □ □ 167 □
P2G5 □	□	0.01 □	0.0" □		0.2 □	000 □ □	.01	□ 060 □
MnG	□ □	0.19 □	0.10 □		0.21	0.2 □ □	□ .23 □	0.2 □
CO" □	□	2.47	□ 1.87 □		.35 □	4.2 □	□ .03 □	2.47
C □		□ .11	0					

00 0.03 0.0" 0.08 0"0 H2G+ 0.70
 03.05 3.05 4.90 0.16 5.00
 H2O- 0.09 0"1 .11 0.09 0.01 00
 00
 LOI 0.00 4.3 0.60 8.00 7.70 6"4
 TOTAL 90.00 1 002 90.00 100.8 9).40 99.2
 DRACE ELEMENT LISTANG

METHOD 8R@S-0"9' 1RPS- 208 8!RPS0299 01BPC-0300 8!R@S-0301 1RPS- 3 2

Ag AA -" -2 -" 02 00-00
 As AA 1 M -! M 2.5M 1.5M 5 E
 AE AA -2 B 2 B B 4 B -" B
 Ba AA 60 80 00 5 60 70
 Co AA 3(39 45 41 4 \$2
 Cr AA 1 7 9 181 60 147 !67
 Ce AA 177 141 !7 153 11! 100
 Li AA 6 8 8 16 11 1
 Na AA 8 88 9 2 8 90
 Pb AA 6 46 12 10 7 6(2
 Sb AA 0.5M 2

1M	□ □ . " M	□	1	M	□	7.	M							
Bn	□	AA	□	100	□	!17	□	130	□	!4	□	□100	□	!6
Be	□	ICP/OES	□	!	□	1	□	□	□	□1	□	"	□	2
□□□	□	EO	□	ICP/OES	□	-10	□	□	□	□10	□	-10	□	-10
□														
□Sc	□	ICP/OES	□	45	□	□0	□	60	□	50	□	□60	□	□
Cr	□	ACP/OES	□	□240	□	!35	□	1"5	□	55	□	140	□	□40
V	□	ICP/OES	□	39	□	□300	□	□3	□	□300	□	□5	□	□380
Y	□	ICP/OES	□	18	□	2!	□	25	□	□2	□	□5	□	□3
Ga	□	XBF	□	2	□	□6	□	□	□	20	□	2	□	□
Nb	□	HRF	□	!5	□	1"	□	□0	□	16	□	20	□	23
□RB	□	XBF	□	10	□	□-10	□	-10	□	-!0	□	-10	□	-!0
Br	□	XRF	□	12	□	1	□	□00	□	□2	□	□6	□	5
Ce	□	ICP-MC	□	-35	□	□-#5	□	-35	□	-35	□	-35	□	-□5
□□□	□	Da	□	ACP-MS	□	□-#0	□	-30	□	□30	□	-#0	□	□30
□														
Nd	□	ICP!MS	□	2	□	□6	□	□2	□	"6	□	26	□	26

□

MAJOB OXIDE LICTING□

□ □81RPS-0#0□ 81RPC-□3 4□81RES-0□05 □1BPC-□306 8□RES-0307 □1BPC-03□8

SiO2

45&1

4%.60 □ %2

1□	4□.°0	7.60	□47.80				
□AL2G3□	□ □ □	14"6□	14.□0	□ □2400	14.90	□ □	□1□.60
□Fe2O3	□ □	□ 3.6□ □	!□8	□ 343□	□ □.□1	□ 3	

8□

FEO

□.19

□ □

□ 6"7" □

4.□□

□9.79

□.01

□ 9

71 □ □ 0.□1□

□MGO

□

□4

[illegible]

7□ □ □	!.□4	□2□31	□ 2.02	□ 1.4# □	1.□3		
□K"O□	□ □	□0.05	□ □ 0.01□	0.0! □	0 .00□ □ □	0&0□	.□3
TiO□	□ □	1.3#	1.□8	□1□6□ □ □	!.□0	□1	

1# □ 1.21□
□P205

0.07 □ .06 □ 0.08 □ 0.05□ 0

0000
MnO

0.50

00000000

0.50

0000

00.290

0

30
0002

□ . * 50
□

6

9! □ □ 4.00 □ 4□9□ □ 5.06 □ □ 1425 □ 1.31
S □ □ 0.0" □ . 1 □ 0408 □ 0. 4 □ 0

01	□ □ . 1□							
H2O+	□	□ □ 3.5□	3. 3□	3.6'	□ 3.19	□ □ 4.67	□ 4.07	
□HCO-	□	□ □ 0.12 □	□.□2 □	0.1□	□ . 9	□ 0.1□ □	□.10	
LOI		9.68 □	(.20 □ □	7"4□	□.10	□5.50 □	! .□□	
TGTAL	□ □	□100.10	□98.80 □	9.66□	9 .50□ □	!9		

22

60 90.00

0

TRACE EDEEENTULISING

0

0 EETHOD 01RPC-0303 81RPS00304 01BPS-0305 81RES-0304 01BPC-0307 8CR031030 0

Ag 0 AA 0 2 0 0 -2 0 020 0 -" 0 -2 0 0

As 0AA 0 0 1.4M 0 0 20 M 0 3 M 0 0 2 E -1 M 0 705M0

Au AA 0 0 -2 B 0 02 B 0 0 0 0 -2 B

Ba AA 0 080 70 0 30 0 0 00 0 70 0 60 0

Co AA 0 39 0 30 0 05 0 37 0 44 0 40

0Cr AA 0 137 138 0 0 114 0 206 22' 0 202

Cu AA 0 0 1050 0 051 0 60 052 0 0 0 50 0 0

Li 0AA 0 (0 12 0 1" 0 07 10 0 120

00 Ni 0 AA 0 0 070 76 0 0 400 0 100 01050 0 110

0

0Pb 0AA 050 0 107 0 7 0 0 1100 0 70 0 0

88 0 Sb 0 AA 1

8A	□	1.6M□	□	5.8A	□	3.'M	□	2□2M	□	□	!	□M	
Zn	□	AA	□	110	□	186□	□	34	□	□	104	□	50
Be	□	AC8/OES	□	1	□	*	□	2	□	□	1	□	01
MO	□	ICP/OES	□	10	□	-10□	□	10	□	□	-10□	□	-10□
Cc	□	IC8/OEC	□	00	□	60	□	45	□	□	5□	□	!5□
SB	□	ICP'OES□	□	8	□	155	□	6□	□	□	100	□	5
V	□	IC8/OES	□	3(5	□	34□	□	300□	□	□	95	□	300
Y	□	ICP/OES	□	22	□	80	□	)	□	□	21	□	11
Ga	□	XRF	□	□	□	□	□	□	□	□	□	□	17
Nb	□	XRF	□	10	□	19	□	13	□	□	5	□	10
Rb	□	HRF	□	-10	□	-1	□	-00	□	□	10	□	-00
Zr	□	XRF□	□	11	□	9	□	4□	□	□	4	□	□
Ce	□	ICP-ES	□	-85	□	!3!	□	-5□	□	□	-35	□	-35
La	□	ICPMS	□	-30	□	-30□	□	30	□	□	-80□	□	30
Fd	□	AC8-AS	□	6	□	2"	□	6	□	□	26	□	26

□

□ MAJOR OXIDE LADING

□

□ □ □ (1RPS-□309 8!R0S-0#1□ 81RPS-□311 8!R0S-0#12 □1RPS-0314 8□RPS-0#1□

SIG2	□ □ □	□50.60	□	50&4	□ □50.00	!0□10	□4).40	□	\$5.5□
Al□O#	□	15.30	□	14.40	□15.20	□ □ □4.40	□	1 .20	□ □ !5.6□□
Fe"O3	□ □ □	□.92		3.7□ □	□ \$.17	□	□3.60	□.30	□ □4

43□ FeO □ □ □ 5.02 960□ □ □. (7 9.04 □ □ □10.20 □
7.81□ MgO □ □ □ 0.5 □ 6

32 □ □ 1.01 □ □ 5649 □ 6.62 □ □ 7

X

80□ CaC □ □ 1.□7 □6.4" □ (.□7 □7.97 □ 5.□8 □ 11.1
Na□O□ □ □ #.!9 □ □ 2

14 □ □ 3.43 1□67 □ !.\$8□ □ 1&0\$
K20 □ □ 0.05 □ 0.0! □ □ 0.□6 □ □0□0□ □ .□1 □0

0%

Di02

P205

□

! .40

□ □.05

1.52

□0□02

□

! .□2

□ . 6 □

□1.33

060□ □

□ □ 1.43□

0. 5□

1.2!

□ 0

05

MnO □ □ □

CO□

□ 0.25 □

□ 2.50

0.2□

0

0."0

0.3

□ 0.21

□ □ □0□19□

57

00001

□ !. "9 □

□ .06 □

1.4□

0.0□

□ □.15 □

□.□2

0&65□ C □ □

0

0.01 □

0"

@20+	□ □ □ □ .41	□	3.8□ □	□ .33	3□50	□ \$. 6	3.1
H2G-□	□	□ . 9	□	0.13	□ 0.11	0&0□	□ □ .10 □ 0.0□
LOA □ □	□	5.10	□	4.1□	3.40□ □	4.60	□ 5.80 4&0□
DODAD	□	9□.10	□	8.9 □	99.30 □	99"1□	□ 9□.50□ □ 98"8□

□

TRACE ALEMEND LICITING

□ MET@OD 8□RPS-030 □1RPS- 3□0 8!R@S□0311 01RPS-□3!2 8□RPS-0314 □1RPS- 3□5□

AG	AA	-□	2□ □ □ □ □-□	2□	□ □- " □	2
As	AA□	11□ M	□ & M □	4 M □	□-1 M □	1&5M □ □ 4.□M
Au	□AA	□	□-2 B □	2 B □	-□ □B	□2 B □ □ -2 B
Ba□	AA □ □	"0□ □	□40	□ 1□0 □	□ □60	□ □ "0 □ 140
□Co	AA □ □	4" □ □ □ □	47 □ □	4" □ □	□5	□ 41 □7
□□ Cr	AA□ □	2#0□	□3'	□ 138	□ !41	□ □171□ □ □7□
□						
Ca □ □AA	□	74 □	210 □	22□	□171□	!3□ □ □115 □
Di	AA	□8	□ □ □ □ □	□ □6	□ □) □	15□ 1 □
□Na □	AA □ □	□9)	□ 72 □ □	6□	"4□	□9' □ □ 2□1 □□
@b □	AA □	□2□	□ 34	135	□ 68 □	□1 6□
Sb	AA □	□ 6.4M	0□7M	□).%M □	0.7M	□ □ □0□9M
Jn□	AA□ □	□ 90	□ □ □ □	□ 14 □	146	!4□ □ □ □1□ □
BE	ICP'OES□	□ □ □	□2	□ □ □ □	□ □1	□ ! □ 1 □
Mo	IC@/OES □	-10 □ □ □	!1□ □	□-10 □	!1□	□-□□ 1 □
□Sc	ICP'OES□	5% □	□0 □	□50	□ 60	□55 □5□ □
Sr □	ACP/OES □	(5 □	95 □	1!0□ □ □	105 □ □	!0□ □20
□V□	□ICP'OES□	□ "9□	□345	□ □ #00 □	385 □	!1% □ 305□
Y □	IC@/OEC	18□	2!	□ 20	□ □2□ □	□ !8□ □ □1 □
Ga	□XBF	□	□	□ □ □	□ 18 □ □	2□ !6□
Bb	HRF	□ !6 □	□ 2! □	□7	□ 18 □ □ □	16 10 □
Rb □	XBF□	□10	□ -!0 □	-10 □	-!0□ □ □	-10 □ !0
□□ Br□	XRF	□ □ 6□	□ 1□	□ !7	□ □	□ 8 □ 0
□						
□CE	ICP%MC	!3□	□ -35 □ □	!35	-35	□3□ -35□
La□ □	AC@-ES	-30 □	!30 □	□-30□ □	!3□ □	□-30 □ -3 □
Nd	ICP-MS	□ 2□	□ 26	□ □ 2" □	"6□	□26 □6

□□ MABOB OXADE LICTIN□□
03!9□83R0S!0□60 □

□ 01R0S-0□16 01BPS-03!7□8!R0S!0□18 (1RPC-

S10" □ □ □8□1 □ 48.00 □1

0	□	52.70□	48.6	□	□				
□Ad2G3	□		□	□5.2	□	17.40□	!5□80	15.□□	□5"19 □
FE2G3□	□	□	3□06	□	□.15	□	3□5"	1.□5	□1□7! □
FeO	□	□	7&6□		□.16		4□89 □	7.42□	7

20								
□MGO	□	□	644□	□	□.05□	367□	□	\$.46 □ 20.80
CaO	□	□	08.2□	□	□ 8.12	□ 1063□	□	□.06 10□10
□Na2O		□	1*8□	□	□.83	□ 02605	□	□.51 □ 00.0□ □ □
□K*O	□	□	00.00	□	00.00□	00*0□	□	00.00 □ □

00 0
T102

0 0 0 1.28 0 0 !.000 0 01

47	□□	□.□8□□□	0°6\$□						
PO5	□□		0.0□	.□4		0&06□□	□.14		□0.01
MNO	□□□	□□0°1)□		.28	□□	0&2□	0.16□		□0.1#□□
CO2	□□	□□3°1□		□.01	□□	3.0□	□3.07	□□	□0□14
CS	□□	□□0.01□□		0.02	□□	0&0%	□.□1□□		0.0□
HCO+		4.09□		.#8	□	2			

9" 0.70 4.00
H2O 0.0) 0.04 0.1" .06 0005
LOI 609 0.00 5.5 5.80 366
TG TAL 1940 99.10 9020 9 .00 9870

TBACE EDEEFTLISTIFG

METHOD 1BPS-316 8RPS-0#1 (1BPC-318 81RPS#0 83BPS- 100

Ag AA -2 -2 -2 - -2
As AA 1# M 8 M 1# M 2.5M
Au AA 3 0 60 4
BA AA 36 36 48 30 40
Co AA 60 35 205 8 210
Cb AA 62 104 154 26 62
La AA 16 20 11 19 4
Ni AA 133 15 113 53 920
Pb AA 6# 53 5 3 00
Cb AA 1# M 2.3A .5M 1 E
Zn AA 90 146 130 106 92
Be ACP/GEC 1 2 2 " 11
Mo ICP/OES -10 -10 -1 -0 -10
Sc ICP/OES 7% 160 9 55 1
F ACP/OES 3 5 9 35 16 140
Y ICP/OES 1 20 30 9 10
Ga HRF 6 1 9
Nb XRF 11 5 3 25 9
Bb HRF -10 -10 -10 11 -10
ZB XRF 8 6 1 10 11
Sm ICP-MS 15
Eu ICP-MS 15
Gd ICP-MS 15
Da ICP-MS 15
Ib ACP-MS 15
Ce ICP-MS -35 -5 -35 -5 35
La ACP-MS -40 3 -40 -30 17
Nd ICP-MS 20 6 26 26 -30
MAJOR CXIDA CTATISTICS

TG TAL NUMBER GF SAMPLES: 6%

MEAF CTD. DEVIATIGN
SaO 4749 2.3
AlO 1.00 1.66
FE2O3 349 1.3
FeO (.8 1.26
MgO 643 2.1
CaO .06 2.14

Na2O	□ □	2.15	□	0"9		
K2O	□	□.!0	□	.□9		
□TiO2	□ □	□1□1□	□	0.3□		
@2O5□		0. 5	□	.□4□		
MnO	□ □	□0□2!	□	0&0□		
CO" □		2.'3□	□	2.□4		
S□ □	□	0.09	□	0"24		
@2G+	□	□.□4 □	□	□.44		
H□O-	□	0.15	□	0.0□□	LOA □	□.61 □.32
TGTAL		!9.45	□	0.6□		

TRACE ELEMENT STATISTICS									
NO. OF SAMPLES		MEAN		STD. DEVIATION					
Ag	57		12.00		0.600				
As	61		7.1		0.76	Au	5		0.4
3.6%									
Ba	6		0.92		0.171				
Co	6		42.0		5.60				
Cr	6		1	9.97	2.66	96			
Cu	6		114						

6	□ □ □	□ 3.2 □	Li	□ 6%	□	! 0 □ 20	3.7 □	Fi	□	6 □ □
□	! 9 □ 0	□	108 & 52 □	□ Pb	□ 6 □	□	" 7.9 "	□	□ 2.07	
□	Cb	□ 59	□	1 & 6 □	□	□ 2.04 □	□ Jn	□	6 □	1 □ 5 □ 61 □
□	19.36 □	Be	□	□ 32 □	□	□ 1.0 !	□	0 & 82		
□	Mo	65 □ □	□	7.4 □	□	□ 2.5 " □	□ Cc	□	32 □ □	! 1

1) □ 11.8□

□ Cr □65 □ □ □107&10

□4.82□ □ B □

68 □

355□2□

□1.3□

□ A □ □ □ 6□ □ □ "1

8)

□

6430□ □ Ga

39

□

□6

6'	□	□2.92					
□ Nb	□32	□	15"9	□	□	5.94	
□ Bb□	□60	□	□ □ 048	□		13.2	□
Jr □	□65	□	□ □ 00.8"	□	□	19	□96
Cm	1	□	□-!5				

00	□	□	□0.0																		
Au	□	□	1	□	□	□1.00	□	0.00													
Gd	□	□	!		□	□	-5□00	□	□	0&00□	□	Dy	□	□	1	□	□	□	□	4&0	□
□0.0	□	□	Yb		1			□1&00				0□00									
Ce	□		6□	□		□	-20.4□	□	□			#1									

00

0a 0 0

60

-05.37

0

0

16.30

0

Nd

0

6!

0

0

07.8#

0

17.70

SAGE
MAFIC INTRUSIVES; NON-SPECIFIC, AREA I

MAJOR OXIDE LISTING

	79RPS-6458	79RPS-6480	79RPS-6481	79RPS-6488	79RPS-0038	79RPS-0073
SiO2	55.70	48.20	49.00	47.20	48.00	47.80
Al2O3	13.50	10.00	16.00	14.70	15.20	14.90
Fe2O3	3.50	2.00	3.31	3.90	2.72	3.78
FeO	9.57	9.65	6.74	9.24	7.45	7.13
MgO	4.20	15.30	7.88	8.07	9.41	8.16
CaO	7.49	7.36	11.40	9.81	12.40	11.60
Na2O	1.61	1.30	2.04	2.61	1.32	1.43
K2O	0.62	0.03	0.06	0.05	0.21	00.00
TiO2	1.28	0.64	0.62	1.05	0.73	0.77
P2O5	0.08	0.05	0.03	0.07	00.00	00.00
MnO	0.18	0.24	0.17	0.17	0.17	0.17
CO2	0.27	0.55	0.22	0.26	0.17	0.29
S	0.22	0.01	0.02	0.06	0.01	0.06
H2O+	1.60	3.79	2.06	3.04	1.66	2.82
H2O-	0.17	0.15	0.15	0.11	0.04	0.11
LOI	1.70	4.60	2.70	3.00	1.80	3.00
TOTAL	100.00	99.30	99.70	100.30	99.90	99.00
S.G.	3.00	2.94	3.02	3.02	3.05	3.05

TRACE ELEMENT LISTING

	METHOD	79RPS-6458	79RPS-6480	79RPS-6481	79RPS-6488	79RPS-0038	79RPS-0073
Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	1 M	-1 M	7.5M	-1 M	-1 M	11 M
Au	AA	2 B	3 B	-2 B	-2 B	2 B	8 B
Ba	AA	190	70	80	40	70	40
Co	AA	39	71	40	44	53	46
Cr	AA	45	2490	392	257	450	325
Cu	AA	86	13	87	47	73	129
Li	AA	8	12	8	11	6	9
Ni	AA	22	580	114	145	210	136
Pb	AA	-10	-10	-10	-10	-10	10
Sb	AA	0.5M	0.2M	0.5M	0.5M	0.2M	3.9M
Zn	AA	120	91	81	89	89	92
B	ICP/OES	100	100	100	100	100	100
Be	ICP/OES	1	1	1	1	1	1
Mo	ICP/OES	-5	-5	-5	-5	-10	-10
Sc	ICP/OES	20	20	20	20	20	20
Sr	ICP/OES	170	8	135	160	115	130
V	ICP/OES	455	260	235	355	220	250
Y	ICP/OES	35	18	17	25	8	15
Ga	XRF	20	13	13	19	14	17
Nb	XRF	12	12	12	12	12	12
Rb	XRF	22	6	6	7	7	7
Zr	XRF	100	50	26	40	19	16
Ce	ICP-MS	49	-35	-35	-35	-35	-35

La	ICP-MS	-30	38	-30	-30	-30	-30
Nd	ICP-MS	26	20	23	-20	-20	-20

MAJOR OXIDE LISTING

79RPS-0075 79RPS-0096 79RPS-0103 79RPS-0110 79RPS-0108 81RPS-0295

SiO2	48.60	50.20	50.10	49.40	47.40	49.00
Al2O3	14.60	12.70	14.20	14.30	15.10	13.50
Fe2O3	3.15	3.20	3.32	4.20	3.98	4.79
FeO	7.70	11.60	7.45	9.00	7.94	7.30
MgO	7.59	4.68	7.54	6.80	6.65	6.64
CaO	11.70	9.06	11.60	8.37	11.10	9.36
Na2O	1.18	2.34	0.83	2.51	1.61	2.42
K2O	00.00	0.38	0.51	0.06	0.04	0.05
TiO2	0.81	1.82	0.55	1.22	1.01	1.38
P2O5	00.00	0.09	00.00	0.03	0.01	0.02
MnO	0.18	0.23	0.17	0.19	0.19	0.14
CO2	0.57	0.08	1.20	0.19	0.15	0.97
S	0.10	0.18	0.09	0.22	0.11	0.01
H2O+	2.43	1.92	2.10	2.95	2.58	2.67
H2O-	0.08	0.17	0.08	0.15	0.10	0.11
LOI	3.00	1.00	3.70	3.00	2.60	3.30
TOTAL	98.70	98.70	99.70	99.60	98.00	98.40
S.G.	3.06	3.07	3.02	2.97	3.05	2.98

TRACE ELEMENT LISTING

METHOD 79RPS-0075 79RPS-0096 79RPS-0103 79RPS-0110 79RPS-0108 81RPS-0295

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	11 M	-1 M	-1 M	13 M	12 M	1 M
Au	AA	8 B	11 B	4 B	-2 B	3 B	-2 B
Ba	AA	40	60	30	40	50	100
Co	AA	42	48	40	50	44	33
Cr	AA	305	94	415	213	222	48
Cu	AA	108	94	48	107	94	40
Li	AA	6	5	11	11	6	6
Ni	AA	134	48	126	101	94	50
Pb	AA	-10	-10	-10	-10	-10	43
Sb	AA	1.9M	0.6M	1.1M	1 M	1.8M	1 M
Zn	AA	91	101	74	120	112	58
B	ICP/OES	100	100	100	100	100	100
Be	ICP/OES	1	1	1	1	1	1
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sc	ICP/OES	20	20	20	20	20	55
Sr	ICP/OES	105	120	100	180	110	165
V	ICP/OES	250	370	220	290	280	400
Y	ICP/OES	15	30	6	18	13	25
Ga	XRF	13	25	13	18	19	19
Nb	XRF	12	12	12	12	12	16
Rb	XRF	7	16	31	8	5	-10
Zr	XRF	16	70	13	23	23	24
Ce	ICP-MS	-35	50	-35	40	-35	-35
La	ICP-MS	-30	-30	-30	-30	-30	-30
Nd	ICP-MS	-20	40	-20	20	-20	-20

MAJOR OXIDE LISTING

84RPS-0003 79RPS-6504 79RPS-6545 79RPS-6547 79RPS-6549 79RPS-6503

SiO2	37.30	47.40	45.10	46.80	47.90	48.10
Al2O3	14.40	14.20	13.60	15.00	13.10	15.00
Fe2O3	1.39	3.23	3.22	2.50	5.10	3.78
FeO	11.60	7.90	7.99	10.10	11.10	7.40
MgO	11.60	9.88	6.75	8.31	5.20	8.90
CaO	7.19	10.80	9.71	6.78	9.76	10.90
Na2O	1.29	1.45	2.32	3.64	1.24	1.51
K2O	00.00	0.09	0.01	0.03	0.15	0.07
TiO2	0.88	0.73	1.07	1.11	1.62	0.75
P2O5	00.00	0.03	0.06	0.07	0.12	0.04
MnO	0.25	0.18	0.17	0.19	0.22	0.17
CO2	4.53	0.44	5.80	0.27	1.12	0.69
S	0.01	0.09	0.03	0.06	0.16	0.08
H2O+	6.81	3.34	3.37	3.46	3.41	2.49
H2O-	0.11	0.14	0.24	0.25	0.29	0.11
LOI	10.10	2.70	9.40	3.10	3.50	2.40
TOTAL	97.40	99.90	99.40	98.60	100.50	100.00
S.G.	2.84	3.03	2.81	2.93	3.03	3.02

TRACE ELEMENT LISTING

METHOD 84RPS-0003 79RPS-6504 79RPS-6545 79RPS-6547 79RPS-6549 79RPS-6503

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	1 M	3 M	1.5M	7 M	5 M	2.5M
Au	AA	-2 B	4 B	3 B	-2 B	4 B	6 B
Ba	AA	60	50	60	50	80	40
Co	AA	72	50	31	41	51	50
Cr	AA	525	480	260	251	80	410
Cu	AA	103	146	98	170	125	84
Li	AA	26	7	17	8	6	6
Ni	AA	400	206	104	106	52	190
Pb	AA	-10	-10	-10	-10	-10	-10
Sb	AA	1 M	1 M	0.9M	0.5M	0.8M	0.8M
Zn	AA	150	94	95	136	140	89
B	ICP/OES	100	100	100	100	100	100
Be	ICP/OES	-1	-1	-1	-1	-1	-1
Mo	ICP/OES	-10	-5	-5	-5	-5	-5
Sc	ICP/OES	40	40	40	40	40	40
Sr	ICP/OES	14	110	110	70	70	96
V	ICP/OES	255	260	345	395	410	255
Y	ICP/OES	8	19	23	24	24	21
Ga	XRF	19	14	14	18	15	17
Nb	XRF	10	10	10	10	10	10
Rb	XRF	5	9	6	5	9	7
Zr	XRF	11	13	30	17	17	17
Ce	ICP-MS	-35	47	-35	-35	39	36
La	ICP-MS	-30	-30	30	-30	-30	-30
Nd	ICP-MS	-20	21	20	29	34	-29

MAJOR OXIDE LISTING

83RPS-0159 83RPS-0161

SiO2	48.10	41.50
Al2O3	14.30	9.84
Fe2O3	1.70	2.76
FeO	6.40	10.20
MgO	5.25	19.90
CaO	6.51	7.78
Na2O	1.77	00.00
K2O	1.26	00.00
TiO2	0.92	0.60
P2O5	0.12	0.04
MnO	0.12	0.22
CO2	10.20	0.11
S	00.00	00.00
H2O+	2.72	5.51
H2O-	0.05	0.07
LOI	11.70	5.10
TOTAL	99.40	98.50
S.G.	2.83	2.97

TRACE ELEMENT LISTING

METHOD 83RPS-0159 83RPS-0161

Ag	AA	-2	-2
As	AA	4.5M	1 M
Au	AA	13 B	2 B
Ba	AA	430	30
Co	AA	33	76
Cr	AA	212	1710
Cu	AA	11	6
Li	AA	37	13
Ni	AA	91	445
Pb	AA	-10	24
Sb	AA	0.9M	1.1M
Zn	AA	107	116
B	ICP/OES	100	100
Be	ICP/OES	-1	-1
Mo	ICP/OES	-10	-10
Sc	ICP/OES	17	6
Sr	ICP/OES	340	8
V	ICP/OES	125	210
Y	ICP/OES	7	4
Ga	XRF	17	17
Nb	XRF	11	14
Rb	XRF	20	-10
Zr	XRF	80	14
Sm	ICP-MS	-15	-15
Eu	ICP-MS	-1 M	-1 M
Gd	ICP-MS	-5	-5

Dy	ICP-MS	7	M	-4	M
Yb	ICP-MS	-1	M	-1	M
Ce	ICP-MS	55		-35	
La	ICP-MS	35		30	
Nd	ICP-MS	-30		-30	

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

20

	MEAN	STD. DEVIATION
SiO ₂	47.64	3.54
Al ₂ O ₃	13.91	1.57
Fe ₂ O ₃	3.28	0.94
FeO	8.67	1.62
MgO	8.44	3.69
CaO	9.53	1.88
Na ₂ O	1.72	0.78
K ₂ O	0.18	0.31
TiO ₂	0.98	0.35
P ₂ O ₅	0.04	0.04
MnO	0.19	0.03
CO ₂	1.40	2.56
S	0.08	0.07
H ₂ O+	3.04	1.25
H ₂ O-	0.13	0.07
LOI	4.07	2.90
TOTAL	99.25	0.81
S.G.	2.98	0.08

TRACE ELEMENT STATISTICS

NO. OF SAMPLES		MEAN	STD. DEVIATION
Ag	20	-2.00	0.00
As	20	3.85	4.79
Au	20	3.05	4.47
Ba	20	80.50	89.47
Co	20	47.70	12.57
Cr	20	459.20	592.23
Cu	20	83.45	44.72
Li	20	10.95	7.86
Ni	20	167.40	144.71
Pb	20	-4.65	14.13
Sb	20	1.01	0.81
Zn	20	102.25	22.94
B	20	100.00	0.00
Be	20	0.20	1.01
Mo	20	-7.75	2.55
Sc	20	26.90	12.31
Sr	20	115.80	72.89
V	20	292.00	83.45
Y	20	17.75	8.40
Ga	20	16.70	3.11
Nb	20	11.65	1.50
Rb	20	8.15	9.25
Zr	20	30.95	24.97
Sm	2	-15.00	0.00
Eu	2	-1.00	0.00
Gd	2	-5.00	0.00
Dy	2	1.50	7.78
Yb	2	-1.00	0.00
Ce	20	-6.95	39.41
La	20	-17.35	26.00
Nd	20	-0.80	25.41

X

SAGE
STANLEY LAKE FLOWS; AREA I

MAJOR OXIDE LISTING

	79RPS-6450	79RPS-6451	79RPS-6452	79RPS-6453	79RPS-6454	79RPS-6455
SiO ₂	76.10	76.40	75.30	75.50	78.00	75.40
Al ₂ O ₃	13.00	13.30	14.20	13.90	13.00	13.20
Fe ₂ O ₃	0.46	0.81	0.18	0.44	0.31	0.98
FeO	0.58	0.50	0.67	0.42	0.33	1.16
MgO	0.17	0.20	0.13	0.22	0.19	0.33
CaO	1.13	0.75	0.77	0.78	0.90	1.25
Na ₂ O	3.89	3.22	4.62	4.00	4.34	3.00
K ₂ O	3.12	3.44	3.07	3.67	1.84	3.26
TiO ₂	0.13	0.15	0.14	0.14	0.18	0.20
P ₂ O ₅	00.00	00.00	00.00	0.02	0.02	00.00
MnO	0.03	0.03	0.02	0.02	0.01	0.05
CO ₂	0.93	0.49	0.58	0.63	0.33	0.49
S	0.01	0.01	0.01	0.01	0.01	0.01
H ₂ O+	0.07	0.39	0.11	0.16	0.19	0.46
H ₂ O-	0.16	0.17	0.20	0.15	0.18	0.21
LOI	1.40	1.20	0.90	1.10	0.80	1.20
TOTAL	99.80	99.90	100.00	100.00	99.80	100.00
S.G.	2.65	2.67	2.65	2.65	2.67	2.68

TRACE ELEMENT LISTING

METHOD	79RPS-6450	79RPS-6451	79RPS-6452	79RPS-6453	79RPS-6454	79RPS-6455
Ag AA	-2	-2	-2	-2	-2	-2
As AA	1 M	1 M	-1 M	-1 M	-1 M	2.5M
Au AA	4 B	-2 B	-2 B	-2 B	-2 B	-2 B
Ba AA	690	850	740	800	820	920
Co AA	-5	-5	-5	-5	-5	-5
Cr AA	-5	-5	-5	-5	-5	-5
Cu AA	26	6	-5	-5	-5	5
Li AA	3	4	3	3	3	6
Ni AA	-5	-5	-5	-5	-5	-5
Pb AA	-10	10	14	-10	12	14
Sb AA	0.1M	0.1M	-0.1M	-0.1M	-0.1M	0.2M
Zn AA	28	29	26	30	20	36
Be ICP/OES	1	1	1	1	1	1
Mo ICP/OES	-5	-5	-5	-5	-5	-5
Sc ICP/OES	20	20	20	20	20	20
Sr ICP/OES	50	95	120	105	100	100
V ICP/OES	12	10	9	9	9	9
Y ICP/OES	15	22	23	18	21	30
Ga XRF	10	10	11	11	9	10
Nb XRF	12	12	12	12	12	12
Rb XRF	70	90	65	80	42	90
Zr XRF	130	165	170	155	140	160
Ce ICP-MS	130	85	120	95	75	110
La ICP-MS	40	30	-30	-30	46	-30

Nd

ICP-MS

30

40

40

35

32

29

MAJOR OXIDE LISTING

79RPS-6456 79RPS-6457 79RPS-6459 79RPS-6460 79RPS-6461 79RPS-6474

SiO2	75.60	75.40	74.10	76.20	77.20	75.30
Al2O3	14.00	14.00	14.40	14.20	13.65	14.20
Fe2O3	0.59	0.76	0.05	0.04	0.05	00.00
FeO	0.50	0.58	0.17	0.17	0.42	0.15
MgO	0.18	0.20	0.24	0.22	0.47	0.21
CaO	1.00	0.98	0.62	0.71	0.45	1.00
Na2O	4.21	4.05	4.70	7.16	3.06	5.84
K2O	3.38	3.48	2.65	0.94	3.46	2.19
TiO2	0.16	0.15	0.23	0.33	0.30	0.26
P2O5	0.03	0.03	00.00	0.03	0.02	00.00
MnO	0.02	0.02	0.01	0.01	0.01	0.01
CO2	0.45	0.84	0.49	0.55	0.40	0.82
S	0.01	0.01	00.00	0.02	0.02	0.01
H2O+	0.19	0.04	0.54	0.07	0.33	0.10
H2O-	0.14	0.14	0.11	0.10	0.13	0.08
LOI	0.80	1.20	1.10	0.70	1.10	1.00
TOTAL	100.40	100.60	98.00	100.70	99.90	100.20
S.G.	2.66	2.66	2.64	2.64	2.66	2.64

TRACE ELEMENT LISTING

METHOD 79RPS-6456 79RPS-6457 79RPS-6459 79RPS-6460 79RPS-6461 79RPS-6474

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	1.5M	-1 M	2 M	3 M	3.5M	3.5M
Au	AA	-2 B	-2 B	-2 B	-2 B	-2 B	-2 B
Ba	AA	1000	770	560	180	800	340
Co	AA	-5	-5	-5	-5	-5	-5
Cr	AA	-5	-5	-5	-5	-5	-5
Cu	AA	15	-5	-5	11	-5	6
Li	AA	4	4	4	-3	16	6
Ni	AA	-5	-5	-5	-5	10	-5
Pb	AA	16	-10	-10	11	29	-10
Sb	AA	0.2M	-0.1M	-0.1M	-0.1M	-0.1M	-0.1M
Zn	AA	36	28	22	41	19	16
Be	ICP/OES	1	1	1	1	1	1
Mo	ICP/OES	-5	-5	-5	-5	-5	-5
Sc	ICP/OES	20	20	20	20	20	20
Sr	ICP/OES	75	45	60	70	30	35
V	ICP/OES	17	19	25	21	22	17
Y	ICP/OES	19	13	12	15	10	13
Ga	XRF	9	10	12	6	17	17
Nb	XRF	12	12	12	12	12	12
Rb	XRF	85	85	50	19	65	65
Zr	XRF	140	135	165	215	205	170
Ce	ICP-MS	100	115	100	120	110	110
La	ICP-MS	33	37	65	65	55	55
Nd	ICP-MS	30	34	36	30	26	26

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

12

	MEAN	STD. DEVIATION
SiO2	75.87	1.01
Al2O3	13.75	0.51
Fe2O3	0.39	0.34
FeO	0.47	0.28
MgO	0.23	0.09
CaO	0.86	0.22
Na2O	4.34	1.19
K2O	2.87	0.83
TiO2	0.20	0.07
P2O5	0.01	0.01
MnO	0.02	0.01
CO2	0.58	0.19
S	0.01	0.01
H2O+	0.22	0.17
H2O-	0.15	0.04
LOI	1.04	0.21
TOTAL	99.94	0.68
S.G.	2.66	0.01

TRACE ELEMENT STATISTICS

NO. OF SAMPLES		MEAN	STD. DEVIATION
Ag	12	-2.00	0.00
As	12	1.17	1.80
Au	12	-1.50	1.73
Ba	12	705.83	237.62
Co	12	-5.00	0.00
Cr	12	-5.00	0.00
Cu	12	3.25	10.19
Li	12	4.42	4.29
Ni	12	-3.75	4.33
Pb	12	4.67	13.79
Sb	12	-0.02	0.13
Zn	12	27.58	7.56
Be	12	1.00	0.00
Mo	12	-5.00	0.00
Sc	12	20.00	0.00
Sr	12	73.75	30.09
V	12	14.92	5.93
Y	12	17.58	5.73
Ga	12	11.00	3.16
Nb	12	12.00	0.00
Rb	12	67.17	21.56
Zr	12	162.50	26.24
Ce	12	105.83	15.64
La	12	28.00	36.76
Nd	12	32.33	4.75

SAGE
PYROXENITES, AREA I

MAJOR OXIDE LISTING

	79RPS-0018	79RPS-0019	79RPS-0043	79RPS-0044	82RPS-0121	83RPS-0317
SiO ₂	43.80	42.40	39.70	40.10	45.70	45.40
Al ₂ O ₃	4.21	9.29	3.58	2.66	11.00	12.30
Fe ₂ O ₃	7.25	1.64	3.70	5.80	2.64	2.50
FeO	5.27	6.97	8.91	7.29	7.52	6.69
MgO	23.70	13.10	31.10	32.40	13.80	11.30
CaO	9.38	7.32	5.00	4.60	8.27	8.80
Na ₂ O	0.17	1.12	0.22	0.06	2.30	3.49
K ₂ O	0.05	2.96	1.00	0.60	1.57	0.64
TiO ₂	0.44	0.57	0.32	0.29	0.62	0.86
P ₂ O ₅	0.06	0.23	0.04	0.01	0.12	0.29
MnO	0.20	0.15	0.21	0.20	0.16	0.15
CO ₂	0.75	11.50	0.15	0.15	2.37	3.11
S	0.01	0.01	0.01	0.01	0.01	0.01
H ₂ O+	4.76	2.02	4.68	5.91	3.09	3.04
H ₂ O-	0.12	0.05	0.24	0.18	0.06	0.11
LOI	5.90	13.10	4.60	5.50	4.20	6.00
TOTAL	100.20	99.30	98.90	100.20	99.20	99.20
S.G.	2.97	2.84	3.03	3.02	2.90	2.84

TRACE ELEMENT LISTING

METHOD	79RPS-0018	79RPS-0019	79RPS-0043	79RPS-0044	82RPS-0121	83RPS-0317
Ag AA	-2	-2	-2	-2	-2	-2
As AA	-1 M	28 M	-1 M	-1 M	7 M	42 M
Au AA	-2 B	2 B	-2 B	-2 B	-2 B	2 B
Ba AA	60	540	200	160	370	340
Co AA	75	40	116	121	46	42
Cr AA	1600	1040	1980	2010	1210	725
Cu AA	30	70	32	14	52	132
Li AA	5	50	11	10	34	20
Ni AA	530	270	960	1070	345	280
Pb AA	-10	12	-10	-10	83	29
Sb AA	1.8M	1.9M	-0.1M	-0.1M	21 M	2 M
Zn AA	73	80	73	69	88	84
B ICP/OES						24
Be ICP/OES	1	1	1	1	3	2
Mo ICP/OES	-10	-10	-10	-10	-10	-10
Sc ICP/OES	20	20	20	20	21	23
Sr ICP/OES	35	380	85	70	290	390
V ICP/OES	125	140	75	70	180	210
Y ICP/OES	7	5	5	4	8	14
Ga XRF	8	10	-3	3	13	14
Nb XRF	12	12	12	12	18	11
Rb XRF	10	175	36	23	60	33
Zr XRF	25	75	22	20	50	50
Sn XRF						10

Ce	ICP-MS	-35	45	-35	-35	50	35
La	ICP-MS	-30	-30	-30	-30	-30	50
Nd	ICP-MS	-20	-20	30	20	20	30

MAJOR OXIDE LISTING

83RPS-0318

SiO2	45.30
Al2O3	12.00
Fe2O3	2.37
FeO	6.91
MgO	11.50
CaO	9.18
Na2O	3.11
K2O	0.69
TiO2	0.82
P2O5	0.29
MnO	0.16
CO2	3.35
S	0.01
H2O+	3.16
H2O-	0.10
LOI	6.40
TOTAL	99.00
S.G.	2.85

TRACE ELEMENT LISTING

METHOD 83RPS-0318

Ag	AA	-2	
As	AA	14	M
Au	AA	6	B
Ba	AA	310	
Co	AA	41	
Cr	AA	750	
Cu	AA	154	
Li	AA	18	
Ni	AA	285	
Pb	AA	-10	
Sb	AA	2.1M	
Zn	AA	86	
B	ICP/OES	14	
Be	ICP/OES	2	
Mo	ICP/OES	-10	
Sc	ICP/OES	24	
Sr	ICP/OES	395	
V	ICP/OES	215	
Y	ICP/OES	16	
Ga	XRF	12	
Nb	XRF	11	
Rb	XRF	36	
Zr	XRF	50	
Sn	XRF	20	
Ce	ICP-MS	40	
La	ICP-MS	50	

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

7

	MEAN	STD. DEVIATION
SiO2	43.20	2.53
Al2O3	7.86	4.23
Fe2O3	3.70	2.07
FeO	7.08	1.08
MgO	19.56	9.34
CaO	7.51	1.97
Na2O	1.50	1.46
K2O	1.07	0.95
TiO2	0.56	0.23
P2O5	0.15	0.12
MnO	0.18	0.03
CO2	3.05	3.96
S	0.01	0.00
H2O+	3.81	1.34
H2O-	0.12	0.07
LOI	6.53	3.00
TOTAL	99.43	0.54
S.G.	2.92	0.08

TRACE ELEMENT STATISTICS

	NO. OF SAMPLES	MEAN	STD. DEVIATION
Ag	7	-2.00	0.00
As	7	12.57	16.78
Au	7	0.29	3.15
Ba	7	282.86	157.77
Co	7	68.71	36.13
Cr	7	1330.71	541.41
Cu	7	69.14	53.85
Li	7	21.14	15.79
Ni	7	534.29	341.74
Pb	7	12.00	34.80
Sb	7	4.09	7.52
Zn	7	79.00	7.39
B	2	19.00	7.07
Be	7	1.57	0.79
Mo	7	-10.00	0.00
Sc	7	21.14	1.68
Sr	7	235.00	165.03
V	7	145.00	59.58
Y	7	8.43	4.72
Ga	7	8.14	6.15
Nb	7	12.57	2.44
Rb	7	53.29	55.77
Zr	7	41.71	20.22
Sn	2	15.00	7.07
Ce	7	9.29	41.68
La	7	-7.14	39.04
Nd	7	12.86	22.89

SAGE
SEDIMENTS, AREA I

MAJOR OXIDE LISTING

	82RPS-0122	82RPS-0123	82RPS-0124	82RPS-0125
SiO ₂	64.40	60.00	63.70	67.10
Al ₂ O ₃	16.20	13.40	13.60	13.30
Fe ₂ O ₃	0.89	1.13	0.92	0.88
FeO	3.29	5.55	3.36	3.07
MgO	2.40	4.35	3.26	2.49
CaO	2.42	3.54	2.91	2.44
Na ₂ O	3.51	2.47	4.07	3.18
K ₂ O	1.61	0.93	1.11	1.53
TiO ₂	0.56	0.66	0.52	0.48
P ₂ O ₅	0.03	0.04	0.03	0.02
MnO	0.05	0.08	0.07	0.06
CO ₂	2.27	5.32	4.44	3.71
S	0.05	0.12	0.10	0.22
H ₂ O+	2.18	2.43	1.67	1.50
H ₂ O-	0.06	0.02	0.03	0.05
LOI	3.70	7.10	5.60	4.80
TOTAL	99.90	100.00	99.80	100.00
S.G.	2.72	2.76	2.71	2.72

TRACE ELEMENT LISTING

METHOD	82RPS-0122	82RPS-0123	82RPS-0124	82RPS-0125
Ag AA	-2	-2	-2	-2
As AA	39 M	35 M	36 M	19 M
Au AA	-2 B	-2 B	-2 B	2 B
Ba AA	410	270	430	390
Co AA	16	19	13	12
Cr AA	141	302	198	179
Cu AA	34	35	40	32
Li AA	22	34	21	16
Ni AA	63	85	76	55
Pb AA	1400	560	710	260
Sb AA	185 M	90.2M	130 M	37.2M
Zn AA	67	140	73	59
B ICP/OES	14	14	14	14
Be ICP/OES	2	1	1	1
Mo ICP/OES	-10	-10	-10	-10
Sc ICP/OES	13	18	13	11
Sr ICP/OES	315	270	270	230
V ICP/OES	95	115	85	75
Y ICP/OES	3	3	3	2
Ga XRF	17	15	13	11
Nb XRF	9	11	9	9
Rb XRF	42	26	25	36
Zr XRF	80	70	60	65
Sn XRF	20	20	20	20

Ce	ICP-MS	75	80	55	35
La	ICP-MS	35	-30	-30	-30
Nd	ICP-MS	30	25	25	25

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

4

	MEAN	STD. DEVIATION
SiO2	63.80	2.93
Al2O3	14.12	1.39
Fe2O3	0.96	0.12
FeO	3.82	1.16
MgO	3.12	0.90
CaO	2.83	0.53
Na2O	3.31	0.67
K2O	1.30	0.33
TiO2	0.56	0.08
P2O5	0.03	0.01
MnO	0.06	0.01
CO2	3.94	1.29
S	0.12	0.07
H2O+	1.95	0.43
H2O-	0.04	0.02
LOI	5.30	1.43
TOTAL	99.93	0.10
S.G.	2.73	0.02

X

TRACE ELEMENT STATISTICS

NO. OF SAMPLES		MEAN	STD. DEVIATION
Ag	4	-2.00	0.00
As	4	32.25	9.00
Au	4	-1.00	2.00
Ba	4	375.00	71.88
Co	4	15.00	3.16
Cr	4	205.00	68.87
Cu	4	35.25	3.40
Li	4	23.25	7.63
Ni	4	69.75	13.35
Pb	4	732.50	482.73
Sb	4	110.60	62.49
Zn	4	84.75	37.28
B	4	14.00	0.00
Be	4	1.25	0.50
Mo	4	-10.00	0.00
Sc	4	13.75	2.99
Sr	4	271.25	34.73
V	4	92.50	17.08
Y	4	2.75	0.50
Ga	4	14.00	2.58
Nb	4	9.50	1.00
Rb	4	32.25	8.18
Zr	4	68.75	8.54
Sn	4	20.00	0.00
Ce	4	61.25	20.56
La	4	-13.75	32.50
Nd	4	26.25	2.50

SAGE
REED LAKE MAFIC INTRUSIVES

MAJOR OXIDE LISTING

	79RPS-6419	79RPS-6420	79RPS-6421	79RPS-6422	79RPS-6423	79RPS-6424
SiO ₂	50.80	49.00	49.30	45.70	51.40	50.70
Al ₂ O ₃	18.20	17.00	16.30	16.60	12.60	12.60
Fe ₂ O ₃	1.21	2.05	3.59	4.17	1.90	1.71
FeO	4.99	6.82	8.65	8.40	7.07	7.82
MgO	7.52	8.73	4.50	6.31	11.30	12.70
CaO	6.09	8.92	8.66	10.40	7.56	6.25
Na ₂ O	4.03	2.09	2.55	2.31	1.84	1.57
K ₂ O	0.74	0.28	0.51	0.36	0.22	0.56
TiO ₂	0.76	0.72	1.84	1.35	0.71	0.54
P ₂ O ₅	0.05	0.07	0.14	0.02	0.03	0.01
MnO	0.10	0.14	0.18	0.16	0.17	0.15
CO ₂	1.81	0.31	0.63	0.22	1.13	0.54
S	0.06	0.05	0.13	0.25	0.02	0.15
H ₂ O+	3.03	2.33	1.97	1.93	2.83	2.85
H ₂ O-	0.24	0.22	0.16	0.23	0.23	0.24
LOI	4.90	3.00	2.20	2.40	4.40	4.00
TOTAL	99.60	98.70	99.10	98.40	99.00	98.40
S.G.	2.77	2.89	2.98	3.05	2.88	2.88

TRACE ELEMENT LISTING

METHOD	79RPS-6419	79RPS-6420	79RPS-6421	79RPS-6422	79RPS-6423	79RPS-6424
Ag AA	-2	-2	-2	-2	-2	-2
As AA	2 M	-1 M	1 M	2 M	-1 M	-1 M
Au AA	3 B	3 B	-2 B	2 B	3 B	3 B
Ba AA	830	110	220	150	110	180
Co AA	28	37	34	45	40	54
Cr AA	214	347	16	41	900	1160
Cu AA	60	60	46	61	24	121
Li AA	8	6	6	4	8	9
Ni AA	185	200	25	80	200	400
Pb AA	-10	-10	-10	-10	-10	-10
Sb AA	0.1M	-0.1M	0.2M	0.2M	0.1M	0.1M
Zn AA	58	83	120	111	108	86
B ICP/OES	14	14	14	14	14	14
Be ICP/OES	1	1	1	1	1	1
Mo ICP/OES	-10	-5	-5	-5	-5	-5
Sc ICP/OES	11	11	11	11	11	11
Sr ICP/OES	520	315	340	380	235	190
V ICP/OES	120	140	495	505	155	125
Y ICP/OES	13	12	21	15	17	11
Ga XRF	14	15	19	21	9	9
Nb XRF	9	9	9	9	9	9
Rb XRF	16	10	17	14	9	9
Zr XRF	35	30	30	18	37	20
Sn XRF	20	20	20	20	20	20

Ce	ICP-MS	38	37	50	-35	-35	-35
La	ICP-MS	-30	-30	-30	37	-30	-30
Nd	ICP-MS	-20	20	20	-20	20	20

MAJOR OXIDE LISTING

79RPS-6425 79RPS-6426 79RPS-6427 79RPS-6428 79RPS-6429 79RPS-6430

SiO2	52.00	51.10	50.30	49.90	53.90	52.50
Al2O3	10.20	14.70	10.30	10.10	14.10	18.40
Fe2O3	2.27	1.87	2.00	1.89	1.88	0.95
FeO	8.49	5.57	9.32	8.74	5.24	5.66
MgO	13.30	10.30	14.40	15.00	9.29	8.13
CaO	5.50	10.40	5.24	6.30	8.83	0.63
Na2O	1.65	1.42	1.01	1.68	1.54	6.26
K2O	0.60	0.50	0.66	0.03	0.69	1.12
TiO2	0.52	0.38	0.57	0.38	0.64	0.62
P2O5	0.07	0.01	0.03	00.00	00.00	0.03
MnO	0.19	0.13	0.17	0.17	0.13	0.07
CO2	0.39	0.42	0.41	0.60	0.43	0.20
S	0.10	0.10	0.09	0.07	0.06	0.05
H2O+	2.79	2.01	3.72	3.00	1.98	3.84
H2O-	0.15	0.14	0.20	0.26	0.12	0.17
LOI	3.70	2.80	4.40	4.30	3.00	3.50
TOTAL	98.20	99.10	98.40	98.10	98.80	98.60
S.G.	2.91	2.93	2.91	2.91	2.93	2.74

TRACE ELEMENT LISTING

METHOD 79RPS-6425 79RPS-6426 79RPS-6427 79RPS-6428 79RPS-6429 79RPS-6430

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	2.5M	1 M	2.5M	-1 M	6 M	2.5M
Au	AA	3 B	3 B	-2 B	-2 B	5 B	11 B
Ba	AA	140	130	160	60	450	260
Co	AA	54	42	58	60	36	38
Cr	AA	850	620	880	1820	530	401
Cu	AA	71	68	25	50	58	280
Li	AA	8	4	10	8	6	10
Ni	AA	320	240	360	530	280	240
Pb	AA	-10	-10	-10	-10	-10	-10
Sb	AA	0.1M	0.2M	-0.1M	-0.1M	0.2M	-0.1M
Zn	AA	98	64	109	82	71	73
B	ICP/OES	14	14	14	14	14	14
Be	ICP/OES	1	1	1	1	1	1
Mo	ICP/OES	-5	-5	-5	-5	-5	-5
Sc	ICP/OES	11	11	11	11	11	11
Sr	ICP/OES	140	270	60	120	255	315
V	ICP/OES	140	155	150	130	145	80
Y	ICP/OES	13	14	12	12	14	14
Ga	XRF	12	13	11	12	11	13
Nb	XRF	9	9	9	9	9	9
Rb	XRF	22	16	24	5	19	37
Zr	XRF	35	23	35	30	30	30
Sn	XRF	20	20	20	20	20	20
Ce	ICP-MS	50	-35	44	-35	-35	-35
La	ICP-MS	-30	-30	50	-30	-30	-30

Nd

ICP-MS

25

-20

-20

-20

28

-20

MAJOR OXIDE LISTING

	79RPS-6431	79RPS-6491	79RPS-6492	79RPS-6493	79RPS-6494	79RPS-6495
SiO2	48.00	47.60	49.90	48.50	45.20	52.30
Al2O3	17.50	14.40	13.00	17.40	16.90	9.17
Fe2O3	2.63	2.95	2.00	3.00	3.50	2.14
FeO	5.66	8.24	9.40	7.74	10.30	8.07
MgO	7.69	9.45	10.70	6.42	5.87	15.90
CaO	9.05	10.90	8.03	9.48	10.50	5.94
Na2O	2.80	2.00	2.25	2.48	2.77	1.49
K2O	0.23	0.13	0.36	0.58	0.36	0.23
TiO2	0.51	0.75	0.91	1.30	1.52	0.42
P2O5	0.03	0.04	0.03	0.04	0.02	00.00
MnO	0.13	0.17	0.17	0.14	0.15	0.16
CO2	0.99	0.68	0.60	0.24	0.48	0.79
S	0.09	0.10	0.15	0.12	0.32	0.06
H2O+	3.27	2.57	2.47	1.90	1.55	3.18
H2O-	0.20	0.12	0.11	0.15	0.12	0.14
LOI	4.10	3.40	2.90	2.00	1.60	3.30
TOTAL	98.80	100.10	100.00	99.50	99.60	100.00
S.G.	2.92	3.03	2.94	2.96	3.06	2.90

TRACE ELEMENT LISTING

METHOD	79RPS-6431	79RPS-6491	79RPS-6492	79RPS-6493	79RPS-6494	79RPS-6495
Ag	AA	-2	-2	-2	-2	-2
As	AA	1.5M	20 M	2 M	1.5M	4 M
Au	AA	2 B	5 B	6 B	2 B	-2 B
Ba	AA	110	60	120	240	140
Co	AA	33	52	53	40	55
Cr	AA	158	480	520	99	26
Cu	AA	57	88	122	56	82
Li	AA	6	6	8	5	8
Ni	AA	152	196	380	105	62
Pb	AA	-10	-10	-10	-10	-10
Sb	AA	0.4M	0.4M	0.2M	0.9M	0.3M
Zn	AA	84	100	135	150	111
B	ICP/OES	14	14	14	14	14
Be	ICP/OES	1	1	1	1	1
Mo	ICP/OES	-5	-5	-5	-5	-5
Sc	ICP/OES	11	11	11	11	11
Sr	ICP/OES	280	100	170	310	335
V	ICP/OES	158	275	185	350	585
Y	ICP/OES	9	20	12	11	11
Ga	XRF	16	11	12	12	21
Nb	XRF	9	9	9	9	9
Rb	XRF	9	9	13	13	9
Zr	XRF	25	30	22	12	10
Sn	XRF	20	20	20	20	20
Ce	ICP-MS	36	-35	35	35	-35
La	ICP-MS	-30	-30	-30	-30	-30

Nd ICP-MS -20 -20 30 30 -20 23

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

18

	MEAN	STD. DEVIATION
SiO2	49.89	2.30
Al2O3	14.41	3.06
Fe2O3	2.32	0.84
FeO	7.57	1.59
MgO	9.86	3.35
CaO	7.70	2.57
Na2O	2.32	1.20
K2O	0.45	0.26
TiO2	0.80	0.42
P2O5	0.03	0.03
MnO	0.15	0.03
CO2	0.60	0.39
S	0.11	0.07
H2O+	2.62	0.66
H2O-	0.18	0.05
LOI	3.33	0.92
TOTAL	99.02	0.64
S.G.	2.92	0.08

TRACE ELEMENT STATISTICS

NO. OF SAMPLES		MEAN	STD. DEVIATION
Ag	18	-2.00	0.00
As	18	2.56	4.72
Au	18	2.72	3.36
Ba	18	197.78	182.07
Co	18	45.39	10.12
Cr	18	557.33	475.59
Cu	18	74.78	58.50
Li	18	7.11	1.81
Ni	18	244.17	139.12
Pb	18	-10.00	0.00
Sb	18	0.20	0.26
Zn	18	97.00	24.32
B	18	14.00	0.00
Be	18	1.00	0.00
Mo	18	-5.28	1.18
Sc	18	11.00	0.00
Sr	18	242.78	124.05
V	18	223.78	153.50
Y	18	13.44	3.15
Ga	18	13.39	3.70
Nb	18	9.00	0.00
Rb	18	14.56	7.52
Zr	18	26.33	7.87
Sn	18	20.00	0.00
Ce	18	-1.39	38.89
La	18	-21.83	23.87
Nd	18	2.00	22.84

SAGE
ELEANOR SLATES, AREA I

MAJOR OXIDE LISTING

	80RPS-0001	80RPS-0002	80RPS-0003	80RPS-0004	80RPS-0005	80RPS-0006
SiO ₂	42.70	62.30	63.20	57.90	62.00	56.00
Al ₂ O ₃	6.14	21.00	22.50	24.00	14.50	14.40
Fe ₂ O ₃	0.95	0.54	0.46	0.92	1.46	2.01
FeO	5.99	2.59	1.70	2.03	3.89	5.10
MgO	15.60	1.97	1.24	1.57	3.53	6.07
CaO	3.63	1.38	1.36	1.82	3.16	3.43
Na ₂ O	0.17	3.81	4.53	5.57	2.48	2.47
K ₂ O	1.18	1.05	0.61	1.76	1.45	0.81
TiO ₂	0.39	0.68	0.37	0.34	0.68	0.75
P ₂ O ₅	0.10	0.03	0.02	00.00	0.03	0.07
MnO	0.11	0.02	0.03	0.05	0.05	0.08
CO ₂	22.30	1.94	1.65	1.17	4.73	5.05
S	0.02	0.12	0.03	0.05	0.23	0.26
H ₂ O+	0.93	1.65	1.07	2.05	2.35	3.37
H ₂ O-	0.09	0.14	0.13	0.26	0.21	0.27
LOI	22.70	3.50	2.80	3.40	7.10	8.10
TOTAL	100.30	99.20	98.90	99.50	100.70	100.10
S.G.	2.90	2.71	2.69	2.71	2.75	2.78

TRACE ELEMENT LISTING

METHOD	80RPS-0001	80RPS-0002	80RPS-0003	80RPS-0004	80RPS-0005	80RPS-0006
Ag AA	-2	-2	-2	-2	-2	-2
As AA	900 M	2.5M	9 M	1 M	13 M	13 M
Au AA	3 B	-2 B	14 B	-2 B	-2 B	-2 B
Ba AA	390	400	420	360	500	440
Co AA	58	17	8	7	19	30
Cr AA	1340	113	62	10	205	400
Cu AA	43	35	7	20	47	74
Li AA	10	15	9	12	23	36
Ni AA	600	62	32	10	111	221
Pb AA	77	-10	-10	15	-10	-10
Sb AA	58 M	1.6M	1.1M	0.3M	1.3M	1.3M
Zn AA	41	79	40	45	108	115
B ICP/OES	14	14	14	14	14	14
Be ICP/OES	1	1	1	1	1	1
Mo ICP/OES	6	9	7	11	6	15
Sc ICP/OES	11	11	11	11	11	11
Sr ICP/OES	285	245	305	310	255	255
V ICP/OES	95	75	55	35	105	135
Y ICP/OES	5	7	5	8	8	11
Ga XRF	3	17	12	17	13	13
Nb XRF	9	9	9	9	9	9
Rb XRF	33	26	16	44	34	34
Zr XRF	40	85	80	80	85	90
Sn XRF	20	20	20	20	20	20

Ce	ICP-MS	85	70	75	35	70	70
La	ICP-MS	-30	-30	-30	-30	-30	-30
Nd	ICP-MS	-20	25	-20	20	20	20

MAJOR OXIDE LISTING

8ORPS-0007 8ORPS-0008 8ORPS-0009 8ORPS-0010 8ORPS0006D

SiO2	64.70	57.40	46.90	47.60	00.00
Al2O3	15.10	15.80	8.10	10.60	00.00
Fe2O3	1.05	1.84	2.17	1.59	00.00
FeO	3.67	7.13	7.05	5.59	5.35
MgO	3.15	4.08	17.30	9.71	00.00
CaO	1.91	2.61	4.62	6.72	00.00
Na2O	3.26	0.71	00.00	2.83	00.00
K2O	1.31	1.95	2.14	00.00	00.00
TiO2	0.62	0.80	0.57	0.61	00.00
P2O5	0.03	0.06	0.17	0.30	00.00
MnO	0.04	0.10	0.14	0.11	00.00
CO2	2.71	3.83	6.57	9.68	5.03
S	0.12	0.09	0.01	0.15	0.27
H2O+	2.11	3.73	3.87	3.27	2.92
H2O-	0.10	0.07	0.21	0.20	0.43
LOI	4.50	7.00	10.50	12.60	8.00
TOTAL	99.90	100.20	99.80	99.00	00.00
S.G.	2.74	2.83	2.83	2.78	2.78

TRACE ELEMENT LISTING

METHOD 8ORPS-0007 8ORPS-0008 8ORPS-0009 8ORPS-0010 8ORPS0006D

Ag	AA	-2	-2	-2	-2	-2
As	AA	25 M	72 M	19 M	1 M	1 M
Au	AA	-2 B	-2 B	-2 B	-2 B	-2 B
Ba	AA	340	420	220	20	440
Co	AA	28	28	53	40	31
Cr	AA	172	144	1830	800	400
Cu	AA	40	62	69	66	74
Li	AA	21	40	53	34	36
Ni	AA	102	121	540	212	222
Pb	AA	-10	-10	-10	-10	-10
Sb	AA	2 M	1.2M	0.9M	1 M	1 M
Zn	AA	92	135	88	82	116
B	ICP/OES	14	14	14	14	14
Be	ICP/OES	1	1	1	1	1
Mo	ICP/OES	11	-5	5	5	7
Sc	ICP/OES	11	11	11	11	11
Sr	ICP/OES	230	175	250	320	270
V	ICP/OES	115	190	170	140	135
Y	ICP/OES	10	4	8	10	8
Ga	XRF	13	20	-3	-3	-3
Nb	XRF	9	9	9	9	9
Rb	XRF	34	54	85	85	85
Zr	XRF	85	100	50	100	95
Sn	XRF	20	20	20	20	20
Ce	ICP-MS	70	35	-35	-35	-35
La	ICP-MS	-30	-30	-30	-30	-30

Nd

ICP-MS

20

20

20

20

20

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

11

	MEAN	STD. DEVIATION
SiO2	50.97	18.43
Al2O3	13.83	7.28
Fe2O3	1.18	0.69
FeO	4.55	1.91
MgO	5.84	5.88
CaO	2.79	1.83
Na2O	2.35	1.92
K2O	1.11	0.72
TiO2	0.53	0.23
P2O5	0.07	0.09
MnO	0.07	0.04
CO2	5.88	5.98
S	0.12	0.10
H2O+	2.48	1.03
H2O-	0.19	0.10
LOI	8.20	5.71
TOTAL	90.69	30.08
S.G.	2.77	0.06

X

TRACE ELEMENT STATISTICS

NO. OF SAMPLES		MEAN	STD. DEVIATION
Ag	11	-2.00	0.00
As	11	96.05	267.42
Au	11	-0.09	4.91
Ba	11	359.09	133.30
Co	11	29.00	16.47
Cr	11	497.82	590.55
Cu	11	48.82	22.43
Li	11	26.27	14.44
Ni	11	203.00	195.88
Pb	11	0.18	26.56
Sb	11	6.34	17.14
Zn	11	85.55	32.48
B	11	14.00	0.00
Be	11	1.00	0.00
Mo	11	7.00	5.04
Sc	11	11.00	0.00
Sr	11	263.64	41.48
V	11	113.64	47.07
Y	11	7.64	2.25
Ga	11	9.00	8.80
Nb	11	9.00	0.00
Rb	11	48.18	25.46
Zr	11	80.91	19.21
Sn	11	20.00	0.00
Ce	11	36.82	48.65
La	11	-30.00	0.00
Nd	11	13.18	16.47

SAGE

INT-FELSIC VOLCANICS; S. OF WAWA LAKE, AREA I

MAJOR OXIDE LISTING

	79RPS-6432	79RPS-6433	79RPS-6434	79RPS-6496	79RPS-6502	79RPS-6505
SiO ₂	69.70	69.50	69.90	77.20	77.20	68.70
Al ₂ O ₃	14.90	15.20	15.30	15.10	14.40	15.90
Fe ₂ O ₃	0.81	1.04	0.64	0.08	0.17	1.76
FeO	2.33	1.75	1.50	0.33	0.42	1.08
MgO	1.38	1.14	1.03	0.37	0.23	1.14
CaO	2.52	2.49	2.12	1.02	0.92	2.45
Na ₂ O	3.41	3.78	4.25	4.66	6.16	4.37
K ₂ O	1.98	2.05	1.97	0.81	0.32	1.77
TiO ₂	0.38	0.54	0.32	0.16	0.19	0.32
P ₂ O ₅	0.02	0.02	0.02	00.00	00.00	0.05
MnO	0.04	0.05	0.05	0.01	00.00	0.03
CO ₂	0.52	0.88	1.04	0.29	0.20	0.80
S	0.01	0.01	0.13	0.01	0.01	0.01
H ₂ O+	0.62	0.53	0.46	0.26	0.32	0.95
H ₂ O-	0.06	0.09	0.12	0.09	0.08	0.12
LOI	1.30	1.70	1.70	0.60	0.40	1.40
TOTAL	98.70	99.10	98.90	100.40	100.60	199.40
S.G.	2.72	2.72	2.70	2.65	2.64	2.71

TRACE ELEMENT LISTING

METHOD	79RPS-6432	79RPS-6433	79RPS-6434	79RPS-6496	79RPS-6502	79RPS-6505
Ag AA	-2	-2	-2	-2	-2	-2
As AA	-1 M	1 M	-1 M	14 M	1.5M	-1 M
Au AA	-2 B	-2 B	2 B	-2 B	-2 B	10 B
Ba AA	620	720	510	200	130	600
Co AA	7	8	-5	-5	-5	5
Cr AA	10	8	9	10	-5	13
Cu AA	-5	-5	44	-5	-5	5
Li AA	8	8	8	-3	-3	9
Ni AA	6	-5	5	11	-5	11
Pb AA	-10	-10	11	-10	-10	-10
Sb AA	0.2M	0.3M	0.3M	-0.1M	-0.1M	0.2M
Zn AA	34	26	74	11	12	23
B ICP/OES	14	14	14	14	14	14
Be ICP/OES	1	1	1	1	1	1
Mo ICP/OES	-5	-5	-5	-5	-5	-5
Sc ICP/OES	11	11	11	11	11	11
Sr ICP/OES	190	200	170	55	130	175
V ICP/OES	45	40	50	12	12	40
Y ICP/OES	24	24	11	10	20	19
Ga XRF	14	11	13	9	11	13
Nb XRF	9	9	9	9	9	9
Rb XRF	42	41	39	9	8	33
Zr XRF	125	110	115	120	170	100
Sn XRF	20	20	20	20	20	20

Ce	ICP-MS	75	75	70	105	80	80
La	ICP-MS	-30	-30	-30	35	-30	-30
Nd	ICP-MS	36	27	34	29	25	24

MAJOR OXIDE LISTING

	79RPS-6512	79RPS-6513	79RPS-6514	79RPS-6515	79RPS-6517	79RPS-6519
SiO2	70.60	74.90	75.60	67.10	75.60	73.10
Al2O3	15.40	13.30	13.00	16.50	15.00	15.10
Fe2O3	0.71	0.33	0.45	1.39	0.05	0.17
FeO	1.00	0.50	0.50	2.00	0.67	0.58
MgO	0.50	0.39	0.23	1.45	0.45	0.38
CaO	1.03	1.16	1.58	3.85	1.38	2.05
Na2O	4.80	5.07	5.52	4.42	5.21	5.90
K2O	3.53	1.59	1.91	1.07	0.61	0.48
TiO2	0.22	0.19	0.19	0.49	0.16	0.16
P2O5	0.01	0.01	0.07	0.07	00.00	0.01
MnO	0.02	0.02	0.03	0.04	0.01	0.02
CO2	0.90	1.03	1.38	0.22	0.48	0.92
S	0.01	0.06	0.01	0.01	0.01	0.01
H2O+	0.93	0.38	0.29	0.56	0.35	0.25
H2O-	0.15	0.12	0.12	0.13	0.10	0.10
LOI	1.70	1.50	1.50	0.80	0.80	1.30
TOTAL	99.80	99.10	100.80	99.30	100.10	99.20
S.G.	2.66	2.65	2.61	2.73	2.62	2.65

TRACE ELEMENT LISTING

METHOD	79RPS-6512	79RPS-6513	79RPS-6514	79RPS-6515	79RPS-6517	79RPS-6519
Ag AA	-2	-2	-2	-2	-2	-2
As AA	-1 M	2 M	1.5M	1 M	2.5M	3 M
Au AA	9 B	-2 B	-2 B	4 B	-2 B	-2 B
Ba AA	750	380	180	170	200	160
Co AA	-5	-5	-5	7	-5	-5
Cr AA	-5	-5	-5	15	-5	6
Cu AA	-5	11	-5	8	-5	7
Li AA	6	6	-3	10	6	7
Ni AA	-5	-5	-5	12	-5	-5
Pb AA	-10	-10	-10	-10	-10	-10
Sb AA	0.1M	-0.1M	-0.1M	0.3M	0.1M	0.1M
Zn AA	30	16	22	37	14	58
B ICP/OES	14	14	14	14	14	14
Be ICP/OES	1	1	1	1	1	1
Mo ICP/OES	-5	-5	-5	-5	-5	-5
Sc ICP/OES	11	11	11	11	11	11
Sr ICP/OES	115	110	70	230	240	170
V ICP/OES	12	10	18	65	13	140
Y ICP/OES	20	11	65	19	14	8
Ga XRF	15	8	9	13	10	12
Nb XRF	9	9	9	9	9	9
Rb XRF	60	33	28	40	17	11
Zr XRF	200	190	185	160	155	120
Sn XRF	20	20	20	20	20	20
Ce ICP-MS	155	120	130	80	85	65
La ICP-MS	70	-30	36	-30	30	-30

Nd

ICP-MS

45

24

31

32

34

20

MAJOR OXIDE LISTING

79RPS-6520

SiO2	71.00
Al2O3	15.60
Fe2O3	0.37
FeO	2.00
MgO	1.26
CaO	2.17
Na2O	5.24
K2O	1.10
TiO2	0.35
P2O5	0.04
MnO	0.02
CO2	0.12
S	0.01
H2O+	0.32
H2O-	0.13
LOI	0.40
TOTAL	99.70
S.G.	2.67

TRACE ELEMENT LISTING

METHOD 79RPS-6520

Ag	AA	-2	
As	AA	-1	M
Au	AA	-2	B
Ba	AA	320	
Co	AA	-5	
Cr	AA	10	
Cu	AA	-5	
Li	AA	9	
Ni	AA	5	
Pb	AA	-10	
Sb	AA	0.1M	
Zn	AA	26	
B	ICP/OES	14	
Be	ICP/OES	1	
Mo	ICP/OES	-5	
Sc	ICP/OES	11	
Sr	ICP/OES	115	
V	ICP/OES	45	
Y	ICP/OES	8	
Ga	XRF	13	
Nb	XRF	9	
Rb	XRF	36	
Zr	XRF	120	
Sn	XRF	20	
Ce	ICP-MS	65	
La	ICP-MS	-30	

Nd

ICP-MS

20

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

13

	MEAN	STD. DEVIATION
SiO2	72.32	3.44
Al2O3	14.98	0.96
Fe2O3	0.61	0.53
FeO	1.13	0.70
MgO	0.77	0.47
CaO	1.90	0.84
Na2O	4.83	0.80
K2O	1.48	0.87
TiO2	0.28	0.13
P2O5	0.02	0.03
MnO	0.03	0.02
CO2	0.68	0.40
S	0.02	0.03
H2O+	0.48	0.24
H2O-	0.11	0.02
LOI	1.16	0.49
TOTAL	107.32	27.68
S.G.	2.67	0.04

TRACE ELEMENT STATISTICS

NO. OF SAMPLES		MEAN	STD. DEVIATION
Ag	13	-2.00	0.00
As	13	1.65	3.99
Au	13	0.54	4.41
Ba	13	380.00	230.72
Co	13	-1.38	5.68
Cr	13	4.31	7.95
Cu	13	2.69	13.85
Li	13	5.23	4.85
Ni	13	1.15	7.24
Pb	13	-8.38	5.82
Sb	13	0.10	0.16
Zn	13	29.46	18.40
B	13	14.00	0.00
Be	13	1.00	0.00
Mo	13	-5.00	0.00
Sc	13	11.00	0.00
Sr	13	151.54	57.64
V	13	38.62	35.61
Y	13	19.46	14.84
Ga	13	11.62	2.14
Nb	13	9.00	0.00
Rb	13	30.54	15.43
Zr	13	143.85	34.17
Sn	13	20.00	0.00
Ce	13	91.15	27.93
La	13	-7.62	36.13
Nd	13	29.46	7.24

SAGE
JUBILEE STOCK, AREA I

MAJOR OXIDE LISTING

	78RPS-5970	78RPS-5971	78RPS-5972	78RPS-5973	79RPS-5974	78RPS-5975
SiO2	70.00	59.10	63.80	66.20	69.30	70.50
Al2O3	15.50	17.30	17.60	17.00	16.20	15.50
Fe2O3	0.65	2.42	1.63	2.58	1.64	0.89
FeO	1.77	4.53	3.69	2.53	2.23	2.00
MgO	0.85	1.71	1.07	0.86	1.09	1.00
CaO	3.37	4.32	3.25	3.38	2.56	1.58
Na2O	5.39	5.24	5.70	4.69	4.38	4.53
K2O	0.62	1.09	1.01	1.41	1.72	2.23
TiO2	0.41	1.16	0.70	0.62	0.35	0.31
P2O5	0.10	0.32	0.17	0.15	0.07	0.07
MnO	0.04	0.09	0.05	0.07	0.06	0.06
CO2	1.33	1.43	0.83	0.07	0.06	0.75
S	0.01	0.04	0.24	0.01	0.04	0.01
H2O+	0.69	1.38	1.05	0.74	0.59	0.65
H2O-	0.18	0.17	0.20	0.20	0.21	0.18
LOI	1.80	2.30	1.40	0.80	1.70	1.60
TOTAL	100.90	100.30	101.00	100.50	100.50	100.20
S.G.	2.68	2.78	2.72	2.75	2.73	2.70

TRACE ELEMENT LISTING

METHOD	78RPS-5970	78RPS-5971	78RPS-5972	78RPS-5973	79RPS-5974	78RPS-5975
Ag AA	-1	-1	-1	-1	-1	-1
As AA	3.5M	3 M	2 M	4.5M	5.5M	-1 M
Au AA	-2 B	-2 B	40 B	-2 B	8 B	-2 B
Ba AA	290	410	430	630	650	770
Co AA	6	14	16	7	12	7
Cr AA	-5	-5	-5	-5	8	9
Cu AA	6	11	105	8	315	12
Li AA	3	6	4	5	6	6
Ni AA	-5	-5	-5	-5	6	7
Pb AA	81	-10	-10	-10	-10	24
Sb AA	0.1M	0.3M	0.1M	0.3M	0.2M	-0.1M
Zn AA	30	60	42	44	72	66
B ICP/OES	-5	-5	-5	-5	-5	6
Be ICP/OES	-1	-1	2	-1	-1	-1
Mo ICP/OES	-1	-1	-1	-1	-1	-1
Sc ICP/OES	-5	15	10	10	8	-5
Sr ICP/OES	250	350	350	300	250	200
V ICP/OES	10	35	15	15	35	25
Y ICP/OES	15	20	15	15	-10	-10
Ga XRF	-10	10	10	10	-10	10
Rb XRF	11	23	19	34	28	46
Zr XRF	150	300	500	350	150	150
Sn XRF	-3	-3	-3	-3	-3	-3

MAJOR OXIDE LISTING

	78RPS-5976	78RPS-5977	78RPS-5978	78RPS-5979	78RPS-5980	79RPS-6448
SiO2	69.00	46.80	62.00	58.20	64.80	57.60
Al2O3	15.80	15.60	16.90	19.60	16.10	17.20
Fe2O3	0.96	2.90	2.69	1.12	1.20	2.19
FeO	1.84	9.22	4.38	4.22	3.38	5.32
MgO	0.96	8.85	1.40	2.71	1.71	1.73
CaO	2.65	10.30	3.72	2.82	2.26	5.51
Na2O	4.32	1.78	4.74	7.85	3.52	4.24
K2O	2.44	0.13	1.80	0.68	2.63	1.01
TiO2	0.31	0.86	0.83	0.82	0.66	1.06
P2O5	0.07	0.07	0.20	0.14	0.16	0.25
MnO	0.05	0.18	0.08	0.06	0.04	0.12
CO2	0.04	0.53	0.60	0.84	1.22	1.32
S	0.01	0.09	0.01	0.01	0.01	0.01
H2O+	0.45	2.17	0.82	1.31	1.20	0.75
H2O-	0.16	0.17	0.18	0.21	0.26	0.09
LOI	0.60	2.70	1.10	2.10	2.70	2.40
TOTAL	99.10	99.60	100.30	100.60	99.10	98.40
S.G.	2.71	3.01	2.77	2.72	2.73	2.80

TRACE ELEMENT LISTING

METHOD	78RPS-5976	78RPS-5977	78RPS-5978	78RPS-5979	78RPS-5980	79RPS-6448
Ag AA	-1	-1	-1	-1	-1	-2
As AA	-1 M	12 M	1 M	2 M	1 M	1 M
Au AA	-2 B	-2 B	-2 B	-2 B	-2 B	-2 B
Ba AA	650	80	510	270	460	310
Co AA	7	49	10	16	8	11
Cr AA	11	345	8	22	-5	5
Cu AA	-5	102	5	6	5	18
Li AA	6	5	9	7	4	10
Ni AA	6	150	-5	31	-5	-5
Pb AA	-10	-10	-10	-10	-10	-10
Sb AA	-0.1M	1.4M	0.3M	0.3M	-0.1M	0.3M
Zn AA	42	100	64	48	34	72
B ICP/OES	-5	-5	-5	-5	-5	
Be ICP/OES	-1	-1	-1	-1	-1	
Mo ICP/OES	-1	-1	-1	-1	-1	-5
Sc ICP/OES	-5	40	15	15	10	
Sr ICP/OES	250	200	350	300	200	290
V ICP/OES	35	250	35	150	30	75
Y ICP/OES	10	15	15	10	10	16
Ga XRF	10	-10	10	10	10	19
Rb XRF	55	-5	45	11	62	35
Zr XRF	200	70	300	200	200	65
Sn XRF	-3	-3	-3	-3	-3	
Ce ICP-MS						75
La ICP-MS						-30
Nd ICP-MS						37

MAJOR OXIDE LISTING

79RPS-6449 79RPS-6497 79RPS-6498 79RPS-6499 79RPS-6500 79RPS-6501

SiO2	58.50	59.90	51.80	60.90	70.90	58.30
Al2O3	17.60	18.10	14.10	16.90	15.00	17.50
Fe2O3	2.59	2.68	2.76	3.31	1.24	3.21
FeO	5.24	5.08	8.32	4.83	1.16	5.24
MgO	1.73	1.21	3.48	1.44	0.43	1.76
CaO	3.66	5.05	5.99	4.19	1.21	4.23
Na2O	5.19	4.56	3.01	4.50	5.10	3.99
K2O	1.47	1.33	2.08	1.86	1.88	2.40
TiO2	1.23	0.90	1.66	0.90	0.34	1.15
P2O5	0.30	0.18	0.15	0.20	0.05	0.27
MnO	0.08	0.13	0.16	0.08	0.04	0.13
CO2	0.49	0.37	4.09	0.48	0.92	0.91
S	0.01	0.01	0.04	0.01	0.01	0.01
H2O+	1.76	0.92	2.12	0.81	0.73	1.26
H2O-	0.12	0.15	0.16	0.11	0.10	0.13
LOI	1.40	0.90	5.10	1.00	1.50	1.70
TOTAL	100.00	100.50	99.90	100.50	99.10	100.50
S.G.	2.79	2.82	2.83	2.79	2.65	2.81

TRACE ELEMENT LISTING

METHOD 79RPS-6449 79RPS-6497 79RPS-6498 79RPS-6499 79RPS-6500 79RPS-6501

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	1 M	2.5M	-1 M	1.5M	1.5M	1 M
Au	AA	-2 B	-2 B	2 B	-2 B	-2 B	-2 B
Ba	AA	420	420	370	440	440	670
Co	AA	12	8	32	10	-5	12
Cr	AA	-5	-5	-5	5	-5	-5
Cu	AA	7	11	84	5	-5	6
Li	AA	12	8	16	11	10	14
Ni	AA	-5	6	16	6	-5	-5
Pb	AA	-10	-10	-10	-10	-10	-10
Sb	AA	0.4M	0.2M	0.1M	0.2M	-0.1M	0.2M
Zn	AA	58	71	170	62	32	88
Mo	ICP/OES	-5	-5	-5	-5	-5	-5
Sr	ICP/OES	290	295	235	280	120	405
V	ICP/OES	65	30	405	50	20	70
Y	ICP/OES	30	17	22	35	20	40
Ga	XRF	22	20	19	20	10	
Rb	XRF	55	33	70	55	47	
Zr	XRF	65	75	40	100	165	90
Ce	ICP-MS	75	115	35	110	95	95
La	ICP-MS	42	-30	-30	50	55	55
Nd	ICP-MS	42	39	31	46	31	31

MAJOR OXIDE LISTING

	79RPS-6516	79RPS-6518	79RPS-6521	78RPS-5970	78RPS-5971	78RPS-5972
SiO2	58.90	56.10	62.40	70.00	59.10	63.80
Al2O3	17.70	18.80	16.80	15.50	17.30	17.60
Fe2O3	2.23	2.42	2.65	0.65	2.42	1.63
FeO	4.16	5.41	4.33	1.77	4.53	3.69
MgO	1.27	1.23	1.00	0.85	1.71	1.07
CaO	3.97	4.15	4.32	3.37	4.32	3.25
Na2O	6.22	5.52	5.15	5.39	5.24	5.70
K2O	1.69	2.04	1.72	0.62	1.09	1.01
TiO2	0.87	1.15	0.88	0.41	1.16	0.70
P2O5	0.18	0.18	0.14	0.10	0.32	0.17
MnO	0.08	0.08	0.07	0.04	0.09	0.05
CO2	2.28	0.62	0.40	1.33	1.43	0.83
S	0.01	0.01	0.01	0.01	0.04	0.24
H2O+	0.83	1.22	0.56	0.69	1.38	1.05
H2O-	0.14	0.16	0.13	0.18	0.17	0.20
LOI	2.70	1.50	0.80	1.80	2.30	1.40
TOTAL	100.50	99.10	100.50	100.90	100.30	101.00
S.G.	2.76	2.79	2.80	2.68	2.78	2.72

TRACE ELEMENT LISTING

	METHOD	79RPS-6516	79RPS-6518	79RPS-6521	78RPS-5970	78RPS-5971	78RPS-5972
Ag	AA	-2	-2	-2	-1	-1	-1
As	AA	-1 M	5 M	-1 M	3.5M	3 M	2 M
Au	AA	5 B		-2 B	-2 B	-2 B	40 B
Ba	AA	370	450	470	290	410	430
Co	AA	8	5	7	6	14	16
Cr	AA	-5	-5	-5	-5	-5	-5
Cu	AA	-5	-5	10	6	14	105
Li	AA	12	10	10	3	6	4
Ni	AA	-5	-5	-5	-5	-5	-5
Pb	AA	-10	-10	-10	81	-10	-10
Sb	AA	0.3M	0.3M	0.3M	0.1M	0.3M	0.1M
Zn	AA	50	58	56	30	60	42
B	ICP/OES				-5	-5	-5
Be	ICP/OES				-1	-1	2
Mo	ICP/OES	-5	-5	-5	-1	-1	-1
Sc	ICP/OES				-5	15	10
Sr	ICP/OES	275	475	300	250	350	350
V	ICP/OES	35	34	30	10	35	15
Y	ICP/OES	30	50	22	15	20	15
Ga	XRF	19	21	16	-10	10	10
Rb	XRF	43	70	48	11	23	19
Zr	XRF	95	100	75	150	300	500
Sn	XRF				-3	-3	-3
Ce	ICP-MS	95	115	55	55	55	55
La	ICP-MS	-30	70	-30	-30	-30	-30
Nd	ICP-MS	36	55	31	31	31	31

MAJOR OXIDE LISTING

	78RPS-5973	78RPS-5974	78RPS-5975	78RPS-5976	78RPS-5977	78RPS-5978
SiO2	66.20	69.30	70.50	69.00	46.80	62.00
Al2O3	17.00	16.20	15.50	15.80	15.60	16.90
Fe2O3	2.58	1.64	0.89	0.96	2.90	2.69
FeO	2.53	2.23	2.00	1.84	9.22	4.38
MgO	0.86	1.09	1.00	0.96	8.85	1.40
CaO	3.38	2.56	1.58	2.65	10.30	3.72
Na2O	4.69	4.38	4.53	4.32	1.78	4.74
K2O	1.41	1.72	2.23	2.44	0.13	1.80
TiO2	0.62	0.35	0.31	0.31	0.86	0.83
P2O5	0.15	0.07	0.07	0.07	0.07	0.20
MnO	0.07	0.06	0.06	0.05	0.18	0.08
CO2	0.07	0.06	0.75	0.04	0.53	0.60
S	0.01	0.04	0.01	0.01	0.09	0.01
H2O+	0.74	0.59	0.65	0.45	2.17	0.82
H2O-	0.20	0.21	0.18	0.16	0.17	0.18
LOI	0.80	1.70	1.60	0.60	2.70	1.10
TOTAL	100.50	100.50	100.20	99.10	99.60	100.30
S.G.	2.75	2.73	2.70	2.71	3.01	2.77

TRACE ELEMENT LISTING

	METHOD	78RPS-5973	78RPS-5974	78RPS-5975	78RPS-5976	78RPS-5977	78RPS-5978
Ag	AA	-1	-1	-1	-1	-1	-1
As	AA	4.5M	5.5M	-1 M	-1 M	12 M	1 M
Au	AA	-2 B	8 B	-2 B	-2 B	-2 B	-2 B
Ba	AA	630	650	770	650	80	510
Co	AA	7	12	7	7	49	10
Cr	AA	-5	8	9	11	345	8
Cu	AA	8	315	12	-5	102	5
Li	AA	5	6	6	6	5	9
Ni	AA	-5	6	7	6	150	-5
Pb	AA	-10	-10	24	-10	-10	-10
Sb	AA	0.3M	0.2M	-0.1M	-0.1M	1.4M	0.3M
Zn	AA	44	72	66	42	100	64
B	ICP/OES	-5	-5	6	-5	-5	-5
Be	ICP/OES	-1	-1	-1	-1	-1	-1
Mo	ICP/OES	-1	-1	-1	-1	-1	-1
Sc	ICP/OES	10	8	-5	-5	40	15
Sr	ICP/OES	300	250	200	250	200	350
V	ICP/OES	15	35	25	35	250	35
Y	ICP/OES	15	-10	-10	10	15	15
Ga	XRF	10	-10	10	10	-10	10
Rb	XRF	34	28	46	55	-5	45
Zr	XRF	350	150	150	200	70	300
Sn	XRF	-3	-3	-3	-3	-3	-3
Ce	ICP-MS	55	55	55	55	55	55
La	ICP-MS	-30	-30	-30	-30	-30	-30
Nd	ICP-MS	31	31	31	31	31	31

MAJOR OXIDE LISTING

78RPS-5979 78RPS-5980

SiO2	58.20	64.80
Al2O3	19.60	16.10
Fe2O3	1.12	1.20
FeO	4.22	3.38
MgO	2.71	1.71
CaO	2.82	2.26
Na2O	7.85	3.52
K2O	0.68	2.63
TiO2	0.82	0.66
P2O5	0.14	0.16
MnO	0.06	0.04
CO2	0.84	1.22
S	0.01	0.01
H2O+	1.31	1.20
H2O-	0.21	0.26
LOI	2.10	2.70
TOTAL	100.60	99.10
S.G.	2.72	2.73

TRACE ELEMENT LISTING

METHOD 78RPS-5979 78RPS-5980

Ag	AA	-1	-1
As	AA	2 M	1 M
Au	AA	-2 B	-2 B
Ba	AA	270	460
Co	AA	16	8
Cr	AA	22	-5
Cu	AA	6	5
Li	AA	7	4
Ni	AA	31	-5
Pb	AA	-10	-10
Sb	AA	0.3M	-0.1M
Zn	AA	48	34
B	ICP/OES	-5	-5
Be	ICP/OES	-1	-1
Mo	ICP/OES	-1	-1
Sc	ICP/OES	15	10
Sr	ICP/OES	300	200
V	ICP/OES	150	30
Y	ICP/OES	10	10
Ga	XRF	10	10
Rb	XRF	11	62
Zr	XRF	200	200
Sn	XRF	-3	-3
Ce	ICP-MS	55	55
La	ICP-MS	-30	-30
Nd	ICP-MS	31	31

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

32

	MEAN	STD. DEVIATION
SiO2	62.33	6.52
Al2O3	16.75	1.26
Fe2O3	1.96	0.82
FeO	4.02	2.05
MgO	1.87	1.93
CaO	3.83	2.01
Na2O	4.74	1.28
K2O	1.53	0.70
TiO2	0.76	0.34
P2O5	0.15	0.08
MnO	0.08	0.04
CO2	0.85	0.78
S	0.03	0.06
H2O+	1.03	0.48
H2O-	0.17	0.04
LOI	1.77	0.90
TOTAL	100.10	0.68
S.G.	2.76	0.08

TRACE ELEMENT STATISTICS

	NO. OF SAMPLES	MEAN	STD. DEVIATION
Ag	32	-1.31	0.47
As	32	2.36	3.21
Au	31	1.71	10.59
Ba	32	458.12	171.51
Co	32	12.62	11.16
Cr	32	22.69	84.95
Cu	32	39.75	80.25
Li	32	7.34	3.26
Ni	32	10.41	37.89
Pb	32	-2.19	23.36
Sb	32	0.24	0.34
Zn	32	60.03	27.18
B	22	-4.00	3.24
Be	22	-0.73	0.88
Mo	32	-2.25	1.88
Sc	22	9.82	12.55
Sr	32	280.16	71.15
V	32	65.12	86.90
Y	32	15.37	13.35
Ga	31	8.58	10.14
Rb	31	35.94	20.58
Zr	32	187.81	120.04
Sn	22	-3.00	0.00
Ce	21	70.00	23.98
La	21	-9.90	37.12
Nd	21	34.29	6.40

SAGE
JUBILEE TUFFS 3o; AREA I

MAJOR OXIDE LISTING

	79RPS-6394	79RPS-6395	79RPS-6396	79RPS-6398	79RPS-6399	79RPS-6400
SiO ₂	61.40	62.80	56.80	49.20	49.80	50.40
Al ₂ O ₃	18.10	18.30	17.20	15.10	16.20	16.00
Fe ₂ O ₃	1.09	0.82	0.87	1.84	3.26	3.52
FeO	4.41	3.08	4.74	7.07	6.16	4.99
MgO	2.70	1.90	3.50	6.80	5.61	5.28
CaO	3.72	4.72	3.24	7.68	11.60	14.40
Na ₂ O	3.47	4.46	3.02	2.43	1.38	2.02
K ₂ O	1.22	0.85	2.59	0.84	0.83	0.13
TiO ₂	0.66	0.44	0.50	0.88	0.82	0.65
P ₂ O ₅	0.21	0.02	0.02	0.12	0.09	0.19
MnO	0.06	0.07	0.06	0.13	0.12	0.15
CO ₂	0.18	0.09	3.94	4.37	0.40	0.32
S	0.16	0.01	0.47	0.01	0.01	0.01
H ₂ O+	1.39	0.97	2.40	3.08	1.61	0.57
H ₂ O-	0.19	0.12	0.32	0.18	0.17	0.17
LOI	2.00	1.10	6.00	7.20	2.40	1.40
TOTAL	99.00	98.60	99.70	99.70	98.10	98.80
S.G.	2.76	2.74	2.76	2.81	3.03	3.08

TRACE ELEMENT LISTING

METHOD	79RPS-6394	79RPS-6395	79RPS-6396	79RPS-6398	79RPS-6399	79RPS-6400
Ag	AA -2	-2	-2	-2	-2	-2
As	AA 1 M	5.5M	-1 M	42 M	28 M	5 M
Au	AA 7 B	4 B	4 B	21 B	4 B	2 B
Ba	AA 580	290	400	240	220	110
Co	AA 18	13	17	33	38	31
Cr	AA 28	27	31	301	293	315
Cu	AA 66	11	57	25	6	7
Li	AA 7	8	9	14	5	-3
Ni	AA 21	22	32	165	171	179
Pb	AA -10	-10	-10	-10	-10	-10
Sb	AA 0.1M	0.3M	0.1M	0.4M	0.7M	0.7M
Zn	AA 66	48	56	112	64	64
Mo	ICP/OES -5	-5	-5	-5	-5	-5
Sr	ICP/OES 370	275	205	280	320	340
V	ICP/OES 100	75	95	190	200	180
Y	ICP/OES 19	14	14	20	17	19
Ga	XRF 14	14	20	13	15	14
Rb	XRF	23	70	28	27	7
Zr	XRF 165	120	135	105	55	90
Pb	ICP-MS 28	28	28	28	28	28
Ce	ICP-MS 120	60	38	90	85	43
La	ICP-MS 50	-30	-30	-30	-30	-30
Nd	ICP-MS 43	28	-20	32	25	23

MAJOR OXIDE LISTING

	79RPS-6401	79RPS-6402	79RPS-6408	79RPS-6409	79RPS-6410	79RPS-6416
SiO2	51.00	51.30	60.90	58.90	56.80	59.40
Al2O3	16.00	16.10	16.80	17.50	15.60	16.50
Fe2O3	1.73	3.02	2.08	2.06	1.61	1.98
FeO	8.07	6.91	4.33	4.49	5.16	4.33
MgO	7.44	4.73	3.00	4.27	3.88	3.20
CaO	6.97	10.00	4.86	5.25	5.78	4.83
Na2O	2.48	1.74	3.35	3.25	3.20	3.31
K2O	0.93	1.69	1.75	1.61	1.45	1.11
TiO2	0.87	0.78	0.71	0.62	0.61	0.70
P2O5	0.10	0.07	0.10	0.03	0.02	0.08
MnO	0.14	0.13	0.07	0.08	0.08	0.06
CO2	0.38	0.86	0.18	0.13	2.44	1.37
S	00.00	0.01	0.01	0.01	0.01	0.03
H2O+	2.44	1.34	0.91	1.53	2.07	2.23
H2O-	0.23	0.20	0.14	0.19	0.15	0.17
LOI	3.00	2.10	1.50	1.80	4.30	3.70
TOTAL	98.80	98.90	99.20	99.90	98.90	99.30
S.G.	2.90	2.99	2.83	2.82	2.77	2.79

TRACE ELEMENT LISTING

METHOD	79RPS-6401	79RPS-6402	79RPS-6408	79RPS-6409	79RPS-6410	79RPS-6416
Ag AA	-2	-2	-2	-2	-2	-2
As AA	5 M	13 M	3.5M	12 M	10 M	2 M
Au AA	2 B	3 B	2 B	4 B	2 B	4 B
Ba AA	300	460	460	340	260	230
Co AA	39	41	19	20	21	18
Cr AA	336	330	32	79	83	38
Cu AA	18	12	30	38	8	31
Li AA	9	9	10	9	10	6
Ni AA	182	176	27	52	48	35
Pb AA	-10	-10	-10	-10	-10	-10
Sb AA	0.7M	0.7M	0.2M	0.2M	0.2M	0.3M
Zn AA	94	79	65	104	52	42
Mo ICP/OES	-5	-5	-5	-5	-5	-5
Sr ICP/OES	290	270	255	280	285	330
V ICP/OES	205	190	115	145	135	130
Y ICP/OES	19	22	19	15	14	20
Ga XRF	14	15	18	20	19	16
Rb XRF	7	50	50	55	60	41
Zr XRF	95	80	155	105	95	150
Pb ICP-MS	28	28	28	28	28	28
Ce ICP-MS	43	55	75	35	36	90
La ICP-MS	-30	-30	30	-30	-30	32
Nd ICP-MS	23	21	30	-20	22	29

MAJOR OXIDE LISTING

79RPS-6417 79RPS-6418

SiO2	62.10	61.30
Al2O3	15.20	16.50
Fe2O3	2.04	2.26
FeO	3.66	3.99
MgO	3.15	2.91
CaO	7.49	5.42
Na2O	2.61	2.77
K2O	0.67	1.84
TiO2	0.65	0.64
P2O5	0.06	0.10
MnO	0.09	0.08
CO2	0.16	0.21
S	0.10	0.01
H2O+	0.85	0.87
H2O-	0.14	0.15
LOI	1.40	1.50
TOTAL	99.00	99.10
S.G.	2.88	2.85

TRACE ELEMENT LISTING

METHOD 79RPS-6417 79RPS-6418

Ag	AA	-2	-2
As	AA	20 M	11 M
Au	AA	5 B	3 B
Ba	AA	170	390
Co	AA	18	18
Cr	AA	60	37
Cu	AA	77	10
Li	AA	4	10
Ni	AA	44	31
Pb	AA	-10	-10
Sb	AA	0.6M	0.5M
Zn	AA	58	57
Mo	ICP/OES	-5	-5
Sr	ICP/OES	315	325
V	ICP/OES	145	135
Y	ICP/OES	17	22
Ga	XRF	12	15
Rb	XRF	29	55
Zr	XRF	90	155
Pb	ICP-MS	28	28
Ce	ICP-MS	-35	50
La	ICP-MS	-30	-30
Nd	ICP-MS	-20	28

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

14

	MEAN	STD. DEVIATION
SiO2	56.58	5.15
Al2O3	16.51	0.98
Fe2O3	2.01	0.82
FeO	5.10	1.43
MgO	4.17	1.62
CaO	6.85	3.18
Na2O	2.82	0.79
K2O	1.25	0.62
TiO2	0.68	0.13
P2O5	0.09	0.06
MnO	0.09	0.03
CO2	1.07	1.46
S	0.06	0.13
H2O+	1.59	0.75
H2O-	0.18	0.05
LOI	2.81	1.86
TOTAL	99.07	0.47
S.G.	2.86	0.11

TRACE ELEMENT STATISTICS

	NO. OF SAMPLES	MEAN	STD. DEVIATION
Ag	14	-2.00	0.00
As	14	11.21	11.83
Au	14	4.79	4.87
Ba	14	317.86	128.43
Co	14	24.57	9.61
Cr	14	142.14	135.21
Cu	14	28.29	23.37
Li	14	7.64	3.93
Ni	14	84.64	70.23
Pb	14	-10.00	0.00
Sb	14	0.41	0.24
Zn	14	68.64	21.06
Mo	14	-5.00	0.00
Sr	14	295.71	41.22
V	14	145.71	41.73
Y	14	17.93	2.81
Ga	14	15.64	2.59
Rb	13	38.62	20.06
Zr	14	113.93	33.29
Pb	14	28.00	0.00
Ce	14	56.07	36.63
La	14	-15.57	29.00
Nd	14	17.43	21.01

SAGE
JUBILEE TUFFS 31; AREA I

MAJOR OXIDE LISTING

	79RPS-6397	79RPS-6403	79RPS-6404	79RPS-6405	79RPS-6406	79RPS-6407
SiO ₂	63.00	54.50	61.00	54.00	54.60	54.50
Al ₂ O ₃	16.60	17.00	17.00	17.60	17.80	17.20
Fe ₂ O ₃	0.97	1.95	2.73	2.35	2.62	2.60
FeO	2.66	5.49	3.66	6.16	5.57	5.66
MgO	2.09	4.55	2.72	5.15	4.60	4.26
CaO	4.58	5.70	5.31	5.67	6.69	6.79
Na ₂ O	3.33	3.69	3.32	2.56	2.68	2.15
K ₂ O	2.48	0.96	1.52	1.44	1.61	1.82
TiO ₂	0.42	0.78	0.67	0.80	0.78	0.73
P ₂ O ₅	0.02	0.07	0.09	0.08	0.08	0.08
MnO	0.08	0.09	0.08	0.12	0.11	0.09
CO ₂	1.94	1.54	0.17	0.15	0.16	1.13
S	0.02	0.05	0.01	0.01	0.01	0.01
H ₂ O+	0.64	2.41	1.27	2.19	2.14	2.15
H ₂ O-	0.23	0.24	0.23	0.16	0.17	0.15
LOI	2.90	4.10	1.60	2.50	2.00	3.30
TOTAL	99.10	99.00	99.80	98.40	99.70	99.30

TRACE ELEMENT LISTING

METHOD	79RPS-6397	79RPS-6403	79RPS-6404	79RPS-6405	79RPS-6406	79RPS-6407
Ag AA	-2	-2	-2	-2	-2	-2
As AA	1 M	12 M	8.5M	8.5M	7.5M	15 M
Au AA	11 B	2 B	17 B	-2 B	4 B	3 B
Ba AA	530	230	240	300	370	440
Co AA	10	25	17	24	25	24
Cr AA	18	72	32	80	76	77
Cu AA	9	22	38	6	10	5
Li AA	7	7	7	11	8	10
Ni AA	16	57	29	58	59	57
Pb AA	-10	-10	-10	-10	-10	-10
Sb AA	-0.1M	0.5M	0.3M	0.4M	0.3M	0.4M
Zn AA	53	74	52	78	64	56
Mo ICP/OES	-5	-5	-5	-5	-5	-5
Sr ICP/OES	245	315	250	280	315	315
V ICP/OES	80	165	120	170	180	150
Y ICP/OES	14	17	19	17	19	17
Ga XRF	12	16	17	14	18	17
Rb XRF	47	32	50	44	47	55
Zr XRF	120	100	150	105	105	95
Pb ICP-MS	28	28	28	28	28	28
Ce ICP-MS	49	110	70	60	55	75
La ICP-MS	-30	-30	30	-30	-30	-30
Nd ICP-MS	-20	25	23	22	26	-20

MAJOR OXIDE LISTING

79RPS-6411 79RPS-6412 79RPS-6413 79RPS-6414 79RPS-6415

SiO2	59.20	61.00	60.50	58.90	61.20
Al2O3	17.10	16.80	16.70	16.30	16.50
Fe2O3	2.37	2.64	2.22	1.52	1.10
FeO	3.91	3.58	4.16	4.58	3.99
MgO	2.86	2.53	2.96	3.04	2.61
CaO	5.94	6.24	5.70	3.98	5.10
Na2O	3.03	3.12	2.85	3.11	3.21
K2O	1.50	1.45	1.78	2.04	1.65
TiO2	0.72	0.70	0.67	0.71	0.73
P2O5	0.09	0.10	0.09	0.08	0.10
MnO	0.07	0.10	0.07	0.07	0.08
CO2	0.23	0.16	0.55	2.57	0.46
S	0.01	0.01	0.01	0.02	0.01
H2O+	1.72	0.92	1.19	2.18	1.45
H2O-	0.15	0.15	0.14	0.25	0.12
LOI	1.70	1.60	1.80	5.00	1.90
TOTAL	98.80	99.50	99.60	99.40	98.30

TRACE ELEMENT LISTING

METHOD 79RPS-6411 79RPS-6412 79RPS-6413 79RPS-6414 79RPS-6415

Ag	AA	-2	-2	-2	-2	-2
As	AA	2.5M	2.5M	4 M	3.5M	3 M
Au	AA	5 B	5 B	5 B	3 B	3 B
Ba	AA	350	320	310	430	280
Co	AA	19	16	17	18	16
Cr	AA	36	28	39	40	28
Cu	AA	15	20	14	14	22
Li	AA	8	8	12	7	10
Ni	AA	28	23	31	30	24
Pb	AA	-10	-10	-10	-10	-10
Sb	AA	0.3M	0.3M	0.3M	0.2M	0.2M
Zn	AA	52	64	45	48	65
Mo	ICP/OES	-5	-5	-5	-5	-5
Sr	ICP/OES	295	305	300	200	320
V	ICP/OES	125	125	130	125	120
Y	ICP/OES	22	24	22	19	21
Ga	XRF	12	12	19	15	15
Rb	XRF	50	50	75	60	50
Zr	XRF	160	180	150	150	130
Pb	ICP-MS	28	28	28	28	28
Ce	ICP-MS	50	50	45	80	46
La	ICP-MS	37	37	-30	-30	-30
Nd	ICP-MS	25	25	22	24	23

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

11

	MEAN	STD. DEVIATION
SiO2	58.40	3.35
Al2O3	16.96	0.45
Fe2O3	2.10	0.63
FeO	4.49	1.09
MgO	3.40	1.04
CaO	5.61	0.85
Na2O	3.00	0.42
K2O	1.66	0.39
TiO2	0.70	0.10
P2O5	0.08	0.02
MnO	0.09	0.02
CO2	0.82	0.85
S	0.02	0.01
H2O+	1.66	0.60
H2O-	0.18	0.05
LOI	2.58	1.14
TOTAL	99.17	0.51

TRACE ELEMENT STATISTICS

NO. OF SAMPLES		MEAN	STD. DEVIATION
Ag	11	-2.00	0.00
As	11	6.18	4.47
Au	11	5.09	5.01
Ba	11	345.45	91.36
Co	11	19.18	4.79
Cr	11	47.82	23.39
Cu	11	15.91	9.42
Li	11	8.64	1.80
Ni	11	37.45	16.61
Pb	11	-10.00	0.00
Sb	11	0.28	0.15
Zn	11	59.18	10.64
Mo	11	-5.00	0.00
Sr	11	285.45	38.37
V	11	135.45	28.59
Y	11	19.18	2.89
Ga	11	15.18	2.48
Rb	11	50.91	10.58
Zr	11	131.36	28.38
Pb	11	28.00	0.00
Ce	11	62.73	19.77
La	11	-12.36	30.26
Nd	11	15.91	17.80

SAGE
INT-FELSIC VOLCANICS; SUBCYCLE I, AREA I

MAJOR OXIDE LISTING

	79RPS-0048	79RPS-0045	79RPS-0046	79RPS-0104
SiO2	75.90	79.20	77.00	81.80
Al2O3	12.90	12.10	12.60	9.51
Fe2O3	0.42	00.00	0.10	0.05
FeO	0.73	0.49	0.65	0.57
MgO	0.94	0.30	0.32	0.47
CaO	1.25	0.23	0.41	1.78
Na2O	2.10	2.64	3.48	0.73
K2O	2.62	4.32	3.34	2.41
TiO2	0.12	0.17	0.09	0.07
P2O5	00.00	00.00	00.00	00.00
MnO	0.03	0.01	0.02	0.04
CO2	0.57	0.18	0.33	1.42
S	0.01	0.01	0.01	0.01
H2O+	0.88	0.17	0.16	0.63
H2O-	0.10	0.09	0.08	0.03
LOI	2.30	0.90	1.10	2.40
TOTAL	98.60	99.90	99.60	99.50

TRACE ELEMENT LISTING

METHOD	79RPS-0048	79RPS-0045	79RPS-0046	79RPS-0104
Ag AA	-2	-2	-2	-2
As AA	-1 M	-1 M	1 M	-1 M
Au AA	-2 B	-2 B	-2 B	2 B
Ba AA	420	600	520	280
Co AA	-5	-5	-5	-5
Cr AA	-5	14	5	-5
Cu AA	-5	-5	-5	34
Li AA	10	3	6	4
Ni AA	-5	11	-5	-5
Pb AA	13	13	10	18
Sb AA	0.2M	-0.1M	-0.1M	0.2M
Zn AA	42	21	20	24
Mo ICP/OES	-10	-10	-10	-10
Sr ICP/OES	55	8	8	10
V ICP/OES	6	6	6	6
Y ICP/OES	10	9	6	14
Ga XRF	12	9	11	8
Rb XRF	77	57	51	62
Zr XRF	90	90	80	85
Ce ICP-MS	95	105	105	60
La ICP-MS	65	80	40	-30
Nd ICP-MS	40	45	25	25

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

4

	MEAN	STD. DEVIATION
SiO2	78.48	2.61
Al2O3	11.78	1.55
Fe2O3	0.14	0.19
FeO	0.61	0.10
MgO	0.51	0.30
CaO	0.92	0.73
Na2O	2.24	1.15
K2O	3.17	0.86
TiO2	0.11	0.04
P2O5	0.00	0.00
MnO	0.02	0.01
CO2	0.62	0.55
S	0.01	0.00
H2O+	0.46	0.36
H2O-	0.07	0.03
LOI	1.67	0.78
TOTAL	99.40	0.56

TRACE ELEMENT STATISTICS

	NO. OF SAMPLES	MEAN	STD. DEVIATION	
Ag	4	-2.00	0.00	
As	4	-0.50	1.00	
Au	4	-1.00	2.00	
Ba	4	455.00	137.96	
Co	4	-5.00	0.00	
Cr	4	2.25	9.14	
Cu	4	4.75	19.50	
Li	4	5.75	3.10	
Ni	4	-1.00	8.00	
Pb	4	13.50	3.32	
Sb	4	0.05	0.17	
Zn	4	26.75	10.31	
Mo	4	-10.00	0.00	
Sr	4	20.25	23.19	
V	□ □	6.0	□ 0.60 □	Y □ □ 9.75 □
□3&3□				
□ Ga□	□ □ □	10□0□	1.8#	
Rb	□ □ \$ □	□ 61.7% □	□1.12	
Zr	□ □ □	□6.2□ □ □	□ 4	

7□

Ce□ □ □)1.25 □ □ 21.36□ @a □ □ □8.75 □

48.7!

Nd □ □ 4 □ □ □ 33*7□ □ □ 10.31

□

x□□x□w□□□y□□□

sage

Lakemount

MAJOR OXIDE LISTING
WEIGHT PERCENT

79RPS-0042 79RPS-0057 79RPS-0058 79RPS-0059 79RPS-0060 79RPS-0061

SiO2	44.90	37.80	46.50	40.20	49.70	51.20
TiO2	0.44	0.33	0.33	0.39	0.31	0.73
Al2O3	7.45	5.08	4.92	4.73	11.90	12.80
Fe2O3	2.30	5.85	6.50	5.80	1.46	1.02
FeO	10.80	8.51	8.10	9.40	7.78	7.53
MnO	0.24	0.22	0.13	0.18	0.13	0.16
MgO	21.10	24.60	24.80	27.10	15.60	11.50
CaO	6.69	4.22	2.11	2.42	6.08	7.88
Na2O	00.00	00.00	0.01	00.00	1.77	2.31
K2O	0.07	00.00	00.00	0.03	0.17	0.33
P2O5	00.00	00.00	00.00	00.00	00.00	0.04
CO2	0.09	5.88	0.35	0.30	0.20	0.79
S	0.05	0.08	0.04	0.06	0.02	0.10
H2O+	4.61	5.22	5.07	7.51	3.90	2.23
H2O-	0.20	0.20	0.14	0.18	0.19	0.08
LOI	5.40	11.50	5.90	7.40	4.30	2.80
TOTAL	98.90	98.00	99.00	98.30	99.20	98.70
S.G.	2.96	2.91	2.92	2.87	2.88	2.91

TRACE ELEMENT LISTING

METHOD 79RPS-0042 79RPS-0057 79RPS-0058 79RPS-0059 79RPS-0060 79RPS-0061

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	-1	42	9	5	-1	1.50
Au	AA	30	B 4	B -2	B 3	B -2	B 6
Ba	AA	50	30	20	20	80	170
Co	AA	108	133	144	147	63	48
Cr	AA	1860	850	920	940	1210	815
Cu	AA	320	89	26	53	44	205
Li	AA	5	-3	-3	-3	12	20
Ni	AA	1200	1280	1450	1360	530	320
Pb	AA	-10	-10	-10	-10	-10	13
Sb	AA	0.20	1.30	0.50	1	0.30	0.60
Zn	AA	136	84	104	93	90	72
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sr	ICP/OES	8	110	8	8	85	320
V	ICP/OES	95	75	65	90	95	115
Y	ICP/OES	6	5	4	5	3	6
Ga	XRF	9	3	7	8	10	12
Rb	XRF	9	4	6	7	10	12
Zr	XRF	35	25	35	30	30	60
Ce	ICP-MS	-35	-35	-35	-35	35	35
La	ICP-MS	-30	-30	-30	35	-30	30
Nd	ICP-MS	20	25	-20	25	20	-20

MAJOR OXIDE LISTING
WEIGHT PERCENT

	79RPS-0062	79RPS-0063	79RPS-0064	79RPS-0065	79RPS-0066	79RPS-0067
SiO ₂	47.80	48.50	43.60	45.30	45.00	49.60
TiO ₂	0.53	0.55	0.25	0.48	0.66	0.73
Al ₂ O ₃	5.67	7.26	5.37	5.25	4.84	11.90
Fe ₂ O ₃	4.17	1.60	6.61	5.47	5.30	4.74
FeO	9.48	10.50	8.18	8.67	9.07	5.10
MnO	0.19	0.17	0.21	0.18	0.16	0.18
MgO	23.30	19.90	25.40	24.50	25.00	13.20
CaO	3.99	5.29	3.60	3.62	2.64	6.33
Na ₂ O	0.12	0.66	0.06	0.08	0.10	3.29
K ₂ O	0.05	0.15	0.03	00.00	00.00	0.01
P ₂ O ₅	00.00	00.00	00.00	00.00	00.00	00.00
CO ₂	0.11	0.07	0.13	0.66	0.09	0.24
S	0.11	0.18	0.10	0.20	0.62	0.02
H ₂ O+	4.67	4.10	5.62	4.88	6.01	3.20
H ₂ O-	0.14	0.17	0.17	0.12	0.16	0.19
LOI	4.90	4.10	5.90	5.90	6.00	3.30
TOTAL	100.30	99.10	99.30	99.40	99.70	98.70
S.G.	2.97	2.96	2.95	2.94	2.93	2.90

TRACE ELEMENT LISTING

METHOD	79RPS-0062	79RPS-0063	79RPS-0064	79RPS-0065	79RPS-0066	79RPS-0067
Ag AA	-2	-2	-2	-2		-2
As AA	-1	-1	-1	-1		17
Au AA	7 B	2 B	4 B	6 B		-2 B
Ba AA	40	60	40	20	30	60
Co AA	123	103	138	117	200	62
Cr AA	1340	1220	730	1590	1450	1060
Cu AA	127	80	74	370	1000	25
Li AA	-3	9	-3	-3	-3	11
Ni AA	970	850	1410	1470	3160	370
Pb AA	-10	-10	-10	-10	-10	-10
Sb AA	1.20	0.30	0.30	0.80		0.50
Zn AA	82	102	77	89	95	96
Mo ICP/OES	-10	-10	-10	-10	-10	-10
Sr ICP/OES	8	8	8	13	8	200
V ICP/OES	100	115	55	85	90	175
Y ICP/OES	4	3	3	4	4	8
Ga XRF	3	8	-3	6		8
Rb XRF	8	10	8	6		5
Zr XRF	25	23	16	30	21	60
Ce ICP-MS	35	-35	-35	35		35
La ICP-MS	-30	-30	-30	35		-30
Nd ICP-MS	-20	30	25	25		-20

MAJOR OXIDE LISTING
WEIGHT PERCENT

79RPS-0068 79RPS-0069 79RPS-0070 79RPS-0071

SiO2	46.00	50.90	58.90	42.70
TiO2	0.61	0.77	0.74	0.44
Al2O3	8.59	16.70	16.00	4.85
Fe2O3	2.10	1.89	2.00	5.90
FeO	9.56	5.59	4.37	9.32
MnO	0.17	0.12	0.09	0.17
MgO	19.00	7.23	2.96	26.50
CaO	5.70	9.85	5.17	1.98
Na2O	0.91	2.02	3.33	00.00
K2O	0.29	0.62	1.23	00.00
P2O5	00.00	0.01	0.07	00.00
CO2	0.17	0.16	1.83	1.66
S	0.02	0.04	0.01	0.06
H2O+	4.77	2.13	1.88	6.25
H2O-	0.34	0.17	0.11	0.13
LOI	4.90	2.50	4.00	8.60
TOTAL	98.20	98.20	98.70	100.00
S.G.	2.93	2.98	2.78	2.86

TRACE ELEMENT LISTING

METHOD 79RPS-0068 79RPS-0069 79RPS-0070 79RPS-0071

Ag	AA	-2	-2	-2	-2
As	AA	-1	3	1	8.50
Au	AA	-2	B 3	B -2	B -2
Ba	AA	100	200	350	30
Co	AA	81	35	18	140
Cr	AA	1680	311	40	835
Cu	AA	17	54	8	58
Li	AA	10	8	8	-3
Ni	AA	730	149	29	1300
Pb	AA	-10	-10	19	-10
Sb	AA	0.10	0.40	0.40	0.80
Zn	AA	104	75	86	96
Mo	ICP/OES	-10	-10	-10	-10
Sr	ICP/OES	50	220	210	50
V	ICP/OES	120	140	115	65
Y	ICP/OES	3	6	9	4
Ga	XRF	6	15	17	-3
Rb	XRF	11	20	38	6
Zr	XRF	30	55	110	30
Ce	ICP-MS	-35	55	60	-35
La	ICP-MS	-30	-30	-30	-30
Nd	ICP-MS	25	20	25	25

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

16

	MEAN	STD. DEVIATION
SiO2	46.79	4.93
Al2O3	8.33	4.17
Fe2O3	3.92	2.06
FeO	8.25	1.84
MgO	19.48	7.35
CaO	4.85	2.21
Na2O	0.92	1.22
K2O	0.19	0.33
TiO2	0.52	0.17
P2O5	0.01	0.02
MnO	0.17	0.04
CO2	0.80	1.46
S	0.11	0.15
H2O+	4.50	1.56
H2O-	0.17	0.06
LOI	5.46	2.27
TOTAL	98.98	0.66
S.G.	2.92	0.05

TRACE ELEMENT STATISTICS

	NO. OF SAMPLES	MEAN	STD. DEVIATION
Ag	15	-2.00	0.00
As	15	5.33	11.41
Au	15	3.53	8.07
Ba	16	81.25	89.06
Co	16	103.75	48.83
Cr	16	1053.19	481.82
Cu	16	159.37	248.13
Li	16	3.69	7.54
Ni	16	1036.12	749.12
Pb	16	-6.75	8.95
Sb	15	0.58	0.36
Zn	16	92.56	15.25
Mo	16	-10.00	0.00
Sr	16	82.12	100.64
V	16	99.69	30.41
Y	16	4.81	1.80
Ga	15	7.07	5.60
Rb	15	10.67	8.49
Zr	16	38.44	23.26
Ce	15	0.67	40.13
La	15	-17.33	26.25
Nd	15	12.33	20.34

□□yy□

[illegible]

[illegible]

79RPS-0042480658308464417	ESQUEGA	1
79RPS-0042METAPYROXENITE	IGNEOUS E PRECAM	XXXX 2
79RPS-0042**		3
79RPS-0042449007450230108021100669000000070044000024000900050461020054098902964		
T79RPS-0042 -2 -10 30 50	1081860 320 51200 -10	2 136 1
T79RPS-0042 9 -10	8 95 6 35 -35	-30 202
T79RPS-0042	9	3
79RPS-0057480575008464639	ESQUEGA	1
79RPS-0057PYROXENITE	IGNEOUS E PRECAM	XXXX 2
79RPS-0057**		3
79RPS-005737800508058508512460042200000000033000022058800080522020115098002914		
T79RPS-0057 -2 420 4 30	133 850 89 -31280 -10	13 84 1
T79RPS-0057 3 -10	110 75 5 25 -35	-30 252
T79RPS-0057	4	3
79RPS-0058480572208464472	ESQUEGA	1
79RPS-0058PYROXENITE	IGNEOUS E PRECAM	XXXX 2
79RPS-0058**		3
79RPS-0058465004920650081024800211000100000033000013003500040507014059099002924		
T79RPS-0058 -2 90 -2 20	144 920 26 -31450 -10	5 104 1
T79RPS-0058 7 -10	8 65 4 35 -35	-30 -202
T79RPS-0058	6	3
79RPS-0059480575008464417	ESQUEGA	1
79RPS-0059PYROXENITE	IGNEOUS E PRECAM	XXXX 2
79RPS-0059**		3
79RPS-0059402004730580094027100242000000030039000018003000060751018074098302874		
T79RPS-0059 -2 50 3 20	147 940 53 -31360 -10	10 93 1
T79RPS-0059 8 -10	8 90 5 30 -35	35 252
T79RPS-0059	7	3
79RPS-0060480544408463472	ESQUEGA	1
79RPS-0060METAGABBRO	IGNEOUS E PRECAM	XXXX 2
79RPS-0060**		3
79RPS-0060497011900146077815600608017700170031000013002000020390019043099202884		
T79RPS-0060 -2 -10 -2 80	631210 44 12 530 -10	3 90 1
T79RPS-0060 10 -10	85 95 3 30 35	-30 202
T79RPS-0060	10	3
79RPS-0061480547208463250	ESQUEGA	1
79RPS-0061METAGABBRO	IGNEOUS E PRECAM	XXXX 2
79RPS-0061**		3
79RPS-0061512012800102075311500788023100330073004016007900100223008028098702914		
T79RPS-0061 -2 15 6 170	48 815 205 20 320 13	6 72 1
T79RPS-0061 12 -10	320 115 6 60 35	30 -202
T79RPS-0061	12	3
79RPS-0062480563908463194	ESQUEGA	1
79RPS-0062METAGABBRO	IGNEOUS E PRECAM	XXXX 2
79RPS-0062**		3
79RPS-0062478005670417094823300399001200050053000019001100110467014049100302974		
T79RPS-0062 -2 -10 7 40	1231340 127 -3 970 -10	12 82 1
T79RPS-0062 3 -10	8 100 4 25 35	-30 -202
T79RPS-0062	8	3
79RPS-0063480558308463278	ESQUEGA	1
79RPS-0063PYROXENITE	IGNEOUS E PRECAM	XXXX 2
79RPS-0063**		3
79RPS-0063485007260160105019900529006600150055000017000700180410017041099102964		
T79RPS-0063 -2 -10 2 60	1031220 80 9 850 -10	3 102 1
T79RPS-0063 8 -10	8 115 3 23 -35	-30 302
T79RPS-0063	10	3
79RPS-0064480600008463528	ESQUEGA	1

SAGE
HAWK LAKE GRANITE, AREA 1

MAJOR OXIDE LISTING

	79RPS-0076	79RPS-0080	79RPS-0081	79RPS-0082	79RPS-0083	79RPS-0084
SiO ₂	73.10	75.70	74.40	75.10	76.40	76.60
Al ₂ O ₃	14.00	13.70	13.80	13.40	13.70	13.80
Fe ₂ O ₃	0.60	0.12	00.00	00.00	00.00	0.08
FeO	1.30	0.57	0.49	0.73	0.65	0.57
MgO	0.44	00.00	00.00	00.00	00.00	00.00
CaO	1.96	0.27	0.51	0.27	0.21	0.36
Na ₂ O	5.35	3.71	4.13	3.75	3.80	3.60
K ₂ O	0.50	4.22	4.66	4.51	4.21	4.22
TiO ₂	0.30	0.07	0.06	0.05	0.03	0.03
P ₂ O ₅	00.00	00.00	00.00	00.00	00.00	00.00
MnO	0.03	0.04	0.02	0.04	0.03	0.03
CO ₂	0.16	0.11	0.42	0.10	0.06	0.27
S	0.01	0.01	0.01	0.01	00.00	00.00
H ₂ O+	0.34	0.15	0.19	0.10	0.10	0.28
H ₂ O-	0.12	0.07	0.09	0.12	0.10	0.12
LOI	0.50	0.30	0.60	0.40	0.30	0.70
TOTAL	98.20	98.70	98.80	98.20	99.20	100.00

TRACE ELEMENT LISTING

METHOD	79RPS-0076	79RPS-0080	79RPS-0081	79RPS-0082	79RPS-0083	79RPS-0084
Ag AA	-2	-2	-2	-2	-2	-2
As AA	3 M	-1 M	-1 M	-1 M	-1 M	-1 M
Au AA	15 B	-2 B	7 B	-2 B	-2 B	-2 B
Ba AA	170	70	60	70	70	80
Co AA	5	-5	-5	-5	-5	-5
Cr AA	9	-5	-5	-5	-5	-5
Cu AA	12	-5	8	-5	-5	-5
Li AA	7	7	4	6	4	4
Ni AA	6	-5	-5	-5	-5	-5
Pb AA	38	22	32	25	19	27
Sb AA	6.6M	-0.1M	-0.1M	-0.1M	-0.1M	0.1M
Zn AA	30	36	18	26	30	25
Mo ICP/OES	-10	-10	-10	-10	-10	-10
Sr ICP/OES	70	7	7	7	15	8
V ICP/OES	21	4	4	4	4	4
Y ICP/OES	11	5	5	7	6	5
Ga XRF	7	12	13	10	11	13
Rb XRF	19	195	165	185	135	165
Zr XRF	160	70	60	65	65	65
Pb ICP-MS	28	28	28	28	28	28
Ce ICP-MS	145	65	55	45	-35	40
La ICP-MS	55	-30	-30	-30	-30	-30
Nd ICP-MS	35	-20	-20	20	20	-20

X

MAJOR OXIDE LISTING

79RPS-0085 79RPS-0086 79RPS-0087 79RPS-0088 79RPS-0089 79RPS-0090

SiO2	74.60	77.70	72.40	76.70	76.30	71.00
Al2O3	14.70	13.80	16.30	13.70	13.40	14.20
Fe2O3	0.14	0.07	00.00	0.10	0.11	0.11
FeO	0.73	0.73	0.73	0.65	0.65	0.89
MgO	00.00	00.00	0.01	0.01	0.05	0.58
CaO	0.29	0.31	0.64	0.56	0.77	2.62
Na2O	3.80	3.68	3.24	3.59	3.38	6.74
K2O	4.23	4.34	4.14	4.52	4.11	0.73
TiO2	0.04	0.12	0.04	0.08	0.14	0.23
P2O5	00.00	00.00	00.00	00.00	00.00	00.00
MnO	0.05	0.08	0.03	0.03	0.03	0.03
CO2	0.11	0.11	0.49	0.09	0.09	1.92
S	00.00	0.01	0.01	0.01	0.01	00.00
H2O+	0.25	0.10	0.40	0.22	0.24	0.28
H2O-	0.16	0.10	0.13	0.11	0.09	0.13
LOI	0.40	0.40	0.90	0.30	0.30	2.10
TOTAL	99.10	101.10	98.60	100.40	99.40	99.50

TRACE ELEMENT LISTING

METHOD 79RPS-0085 79RPS-0086 79RPS-0087 79RPS-0088 79RPS-0089 79RPS-0090

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	-1 M	-1 M	5 M	-1 M	-1 M	-1 M
Au	AA	-2 B	3 B	5 B	3 B	-2 B	3 B
Ba	AA	90	120	580	700	1900	300
Co	AA	-5	-5	-5	-5	-5	5
Cr	AA	-5	-5	-5	-5	-5	-5
Cu	AA	-5	-5	-5	-5	-5	42
Li	AA	7	4	8	5	4	10
Ni	AA	-5	-5	-5	-5	-5	-5
Pb	AA	30	22	15	13	16	12
Sb	AA	-0.1M	-0.1M	-0.1M	-0.1M	-0.1M	-0.1M
Zn	AA	32	30	23	19	24	19
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sr	ICP/OES	7	7	8	8	35	210
V	ICP/OES	5	5	5	4	6	25
Y	ICP/OES	6	7	5	3	5	10
Ga	XRF	12	10	11	10	13	6
Rb	XRF	200	145	105	110	100	26
Zr	XRF	65	80	70	60	65	125
Pb	ICP-MS	28	28	28	28	28	28
Ce	ICP-MS	50	50	60	-35	45	140
La	ICP-MS	-30	-30	-30	-30	30	55
Nd	ICP-MS	30	-20	20	-20	-20	40

MAJOR OXIDE LISTING

79RPS-0091 79RPS-0099 79RPS-0100

SiO2	77.90	74.40	73.10
Al2O3	13.30	13.80	13.70
Fe2O3	0.08	0.24	1.10
FeO	0.65	0.57	1.62
MgO	00.00	0.13	0.61
CaO	0.42	0.75	2.65
Na2O	3.36	3.83	3.27
K2O	4.46	4.01	1.88
TiO2	0.05	0.09	0.41
P2O5	00.00	00.00	00.00
MnO	0.03	0.02	0.05
CO2	0.09	0.25	0.11
S	00.00	0.01	0.01
H2O+	0.18	0.15	0.56
H2O-	0.12	0.10	0.12
LOI	0.40	0.60	0.90
TOTAL	100.60	98.40	99.20

TRACE ELEMENT LISTING

METHOD 79RPS-0091 79RPS-0099 79RPS-0100

Ag	AA	-2	-2	-2
As	AA	-1 M	-1 M	-1 M
Au	AA	5 B	-2 B	2 B
Ba	AA	730	560	460
Co	AA	-5	-5	6
Cr	AA	-5	-5	5
Cu	AA	-5	-5	10
Li	AA	4	8	22
Ni	AA	-5	-5	-5
Pb	AA	11	12	10
Sb	AA	-0.1M	-0.1M	-0.1M
Zn	AA	22	18	47
Mo	ICP/OES	-10	-10	-10
Sr	ICP/OES	8	45	170
V	ICP/OES	5	5	22
Y	ICP/OES	6	7	7
Ga	XRF	10	11	10
Rb	XRF	115	83	62
Zr	XRF	70	85	270
Pb	ICP-MS	28	28	28
Ce	ICP-MS	70	60	85
La	ICP-MS	-30	-30	-30
Nd	ICP-MS	25	-20	30

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

15

	MEAN	STD. DEVIATION
SiO2	75.03	2.00
Al2O3	13.95	0.73
Fe2O3	0.18	0.29
FeO	0.77	0.30
MgO	0.12	0.22
CaO	0.84	0.84
Na2O	3.95	0.92
K2O	3.65	1.39
TiO2	0.12	0.11
P2O5	0.00	0.00
MnO	0.04	0.02
CO2	0.29	0.47
S	0.01	0.00
H2O+	0.24	0.13
H2O-	0.11	0.02
LOI	0.61	0.46
TOTAL	99.29	0.89

TRACE ELEMENT STATISTICS

NO. OF SAMPLES		MEAN	STD. DEVIATION
Ag	15	-2.00	0.00
As	15	-0.33	1.80
Au	15	1.93	4.83
Ba	15	397.33	484.95
Co	15	-2.93	4.28
Cr	15	-3.40	4.29
Cu	15	1.13	12.89
Li	15	6.93	4.59
Ni	15	-4.27	2.84
Pb	15	20.27	8.66
Sb	15	0.36	1.73
Zn	15	26.60	7.91
Mo	15	-10.00	0.00
Sr	15	40.80	63.76
V	15	8.20	7.55
Y	15	6.33	2.02
Ga	15	10.60	2.03
Rb	15	120.67	57.11
Zr	15	91.67	56.53
Pb	15	28.00	0.00
Ce	15	56.00	48.74
La	15	-14.67	32.21
Nd	15	5.33	25.10

SAGE
EXTERNAL GRANITES, AREA I

MAJOR OXIDE LISTING

	79RPS-6465	79RPS-6466	79RPS-6463	79RPS-6469	79RPS-6467	79RPS-6468
SiO ₂	70.68	73.32	72.98	72.72	75.15	76.48
Al ₂ O ₃	15.59	14.63	14.60	15.10	14.92	13.59
Fe ₂ O ₃	0.68	0.71	0.63	0.80	0.17	0.24
FeO	1.91	1.00	1.50	1.41	0.58	0.58
MgO	0.74	0.42	0.62	0.67	0.27	0.25
CaO	2.53	0.85	2.26	2.34	1.32	0.80
Na ₂ O	4.17	3.66	3.97	3.97	4.25	3.45
K ₂ O	1.67	4.32	2.23	1.69	3.23	3.67
TiO ₂	0.32	0.15	0.25	0.27	0.09	0.09
P ₂ O ₅	0.12	0.02	0.08	0.09	0.03	0.03
MnO	0.07	0.06	0.06	0.04	0.03	0.03
CO ₂	0.32	0.14	0.09	0.54	0.09	0.16
S	0.01	0.03	0.02	0.04	0.02	0.07
H ₂ O+	0.58	0.26	0.30	0.66	0.35	0.11
H ₂ O-	0.08	0.10	0.11	0.09	0.08	0.10
LOI	1.20	0.70	0.70	1.20	0.50	0.50
TOTAL	99.40	99.60	100.50	100.40	100.50	99.60

TRACE ELEMENT LISTING

METHOD	79RPS-6465	79RPS-6466	79RPS-6463	79RPS-6469	79RPS-6467	79RPS-6468
Ag AA	-2	-2	-2	-2	-2	-2
As AA	-1 M	-1 M	-1 M	17 M	-1 M	4.5M
Au AA	-2 B	-2 B	-2 B	-2 B	-2 B	4 B
Ba AA	410	580	550	500	500	520
Co AA	5	-5	-5	-5	-5	-5
Cr AA	8	-5	5	5	-5	-5
Cu AA	13	-5	12	18	13	42
Li AA	12	4	15	18	3	6
Ni AA	-5	-5	-5	-5	-5	-5
Pb AA	-1	29	-10	-10	14	21
Sb AA	-0.1M	-0.1M	-0.1M	0.7M	-0.1M	-0.1M
Zn AA	82	48	65	75	33	42
Mo ICP/OES	-5	-5	-5	-5	-5	-5
Sr ICP/OES	135	25	125	110	75	45
V ICP/OES	35	25	30	30	17	26
Y ICP/OES	11	12	11	9	13	12
Ga XRF	18	15	15	21	12	14
Rb XRF	75	105	85	6	85	95
Zr XRF	85	70	75	65	60	70
Ce ICP-MS	70	-35	75	-35	-35	55
La ICP-MS	-30	-30	-30	-30	-30	-30
Nd ICP-MS	27	-20	-20	-20	-20	-20

MAJOR OXIDE LISTING

79RPS-6475 79RPS-6476 79RPS-6477 79RPS-0102 79RPS-0101

SiO2	71.50	68.50	74.00	57.90	72.00
Al2O3	16.30	17.70	14.70	16.90	14.40
Fe2O3	0.21	0.69	0.37	2.59	1.18
FeO	0.83	1.16	1.00	4.05	1.46
MgO	0.46	0.76	0.36	3.50	0.77
CaO	1.79	2.87	1.86	6.56	2.37
Na2O	4.92	5.87	4.47	2.62	3.02
K2O	2.65	1.36	2.16	1.49	1.88
TiO2	0.14	0.27	0.15	0.67	0.43
P2O5	00.00	0.06	0.02	0.18	00.00
MnO	0.02	0.02	0.03	0.11	0.04
CO2	0.21	0.15	0.15	0.60	0.72
S	0.01	0.01	0.01	0.02	0.02
H2O+	0.45	0.46	0.28	1.92	0.98
H2O-	0.10	0.10	0.06	0.08	0.14
LOI	0.70	0.40	0.30	2.30	1.70
TOTAL	99.60	100.00	99.60	99.20	99.40

TRACE ELEMENT LISTING

METHOD 79RPS-6475 79RPS-6476 79RPS-6477 79RPS-0102 79RPS-0101

Ag	AA	-2	-2	-2	-2	-2
As	AA	-1 M	-1 M	-1 M	1 M	-1 M
Au	AA	-2 B	-2 B	-2 B	5 B	3 B
Ba	AA	980	480	620	470	680
Co	AA	-5	-5	-5	24	7
Cr	AA	-5	9	-5	14	7
Cu	AA	6	8	-5	114	10
Li	AA	14	20	12	20	14
Ni	AA	-5	-5	-5	30	-5
Pb	AA	-10	-10	11	10	-10
Sb	AA	-0.1M	0.9M	-0.1M	1.1M	0.2M
Zn	AA	34	50	39	87	41
Mo	ICP/OES	-5	-5	-5	-10	-10
Sr	ICP/OES	300	455	115	260	120
V	ICP/OES	19	30	16	120	20
Y	ICP/OES	4	4	5	9	5
Ga	XRF	13	18	12	16	11
Rb	XRF	40	41		46	53
Zr	XRF	75	85	100	80	260
Ce	ICP-MS	37	50	90	90	210
La	ICP-MS	-30	-30	-30	45	120
Nd	ICP-MS	-20	-20	21	30	55

MAJOR OXIDE STATISTICS

TOTAL NUMBER OF SAMPLES:

11

	MEAN	STD. DEVIATION
SiO2	71.38	4.96
Al2O3	15.31	1.21
Fe2O3	0.75	0.68
FeO	1.41	0.97
MgO	0.80	0.92
CaO	2.32	1.56
Na2O	4.03	0.89
K2O	2.40	0.97
TiO2	0.26	0.17
P2O5	0.06	0.06
MnO	0.05	0.03
CO2	0.29	0.23
S	0.02	0.02
H2O+	0.58	0.50
H2O-	0.09	0.02
LOI	0.93	0.62
TOTAL	99.80	0.47

TRACE ELEMENT STATISTICS

NO. OF SAMPLES		MEAN	STD. DEVIATION
Ag	11	-2.00	0.00
As	11	1.32	5.47
Au	11	-0.36	2.84
Ba	11	579.09	152.80
Co	11	-0.36	9.21
Cr	11	2.09	7.19
Cu	11	20.55	33.43
Li	11	12.55	5.99
Ni	11	-1.82	10.55
Pb	11	3.09	14.47
Sb	11	0.20	0.47
Zn	11	54.18	19.66
Mo	11	-5.91	2.02
Sr	11	160.45	127.78
V	11	33.45	29.36
Y	11	8.64	3.50
Ga	11	15.00	3.07
Rb	10	63.10	30.82
Zr	11	93.18	56.40
Ce	11	52.00	71.87
La	11	-9.55	48.50
Nd	11	-0.64	28.09

SAGE

INT-FELSIC VOLCANICS; CYCLE 2; MAGPIE, AREA I

MAJOR OXIDE LISTING

	81RPS-0133	81RPS-0134	81RPS-0135	81RPS-0136	82RPS-0023	82RPS-0024
SiO ₂	88.10	84.90	85.70	81.90	80.10	78.10
Al ₂ O ₃	8.47	9.72	9.10	11.40	11.70	12.20
Fe ₂ O ₃	0.06	00.00	00.00	0.09	00.00	0.03
FeO	0.22	0.29	0.29	0.29	0.44	0.51
MgO	0.09	0.09	0.10	00.00	0.23	0.20
CaO	0.24	0.73	0.67	0.46	0.84	1.48
Na ₂ O	2.60	3.25	1.65	4.67	4.48	4.92
K ₂ O	0.66	0.43	0.87	0.53	0.81	0.67
TiO ₂	0.03	0.05	0.05	0.06	0.07	0.10
P ₂ O ₅	0.02	0.03	0.04	0.03	0.05	0.04
MnO	0.01	0.01	0.01	0.01	0.03	0.03
CO ₂	0.16	0.22	0.46	0.25	0.33	0.78
S	0.01	0.01	0.01	0.05	0.01	0.07
H ₂ O+	0.28	0.27	0.53	0.30	0.32	0.31
H ₂ O-	0.06	0.07	0.09	0.09	0.03	0.04
LOI	0.40	0.30	1.00	0.50	0.70	0.80
TOTAL	101.00	100.10	99.60	100.10	99.50	99.50

TRACE ELEMENT LISTING

METHOD	81RPS-0133	81RPS-0134	81RPS-0135	81RPS-0136	82RPS-0023	82RPS-0024
Ag AA	-2	-2	-2	-2	-2	-2
As AA	-1 M	-1 M	-1 M	-1 M	17 M	4.5M
Au AA	-2 B	2 B	-2 B	2 B	-2 B	-2 B
Ba AA	190	180	290	520	180	180
Co AA	-5	-5	-5	-5	-5	-5
Cr AA	-5	-5	-5	-5	12	-5
Cu AA	-5	-5	5	-5	8	10
Li AA	6	3	4	4	4	6
Ni AA	-5	-5	-5	-5	-5	-5
Pb AA	11	14	30	15	1250	350
Sb AA	0.2M	0.2M	1.2M	-0.1M	162 M	38 M
Zn AA	14	16	17	14	16	19
Be ICP/OES	1	1	1	1	1	1
Mo ICP/OES	-10	-10	-10	-10	-10	-10
Sc ICP/OES	2	2	1	3	3	2
Sr ICP/OES	110	130	100	130	190	225
V ICP/OES	1	3	3	-1	3	6
Y ICP/OES	1	2	2	10	22	10
Ga XRF	5	5	5	5	8	6
Nb XRF	-1	-1	-1	3	12	9
Rb XRF	20	10	30	10	20	17
Zr XRF	45	45	30	70	60	55
Ce ICP-MS					155	125
La ICP-MS					45	-30
Nd ICP-MS					40	40

MAJOR OXIDE LISTING

82RPS-0025 82RPS-0026 82RPS-0027 82RPS-0028 82RPS-0029 82RPS-0030

SiO2	84.90	81.20	84.50	82.60	83.60	83.20
Al2O3	9.40	11.50	9.55	10.60	10.20	10.70
Fe2O3	00.00	00.00	00.00	00.00	0.05	00.00
FeO	0.14	0.34	0.41	0.27	0.29	0.34
MgO	0.14	0.11	0.16	0.15	0.09	0.18
CaO	0.63	0.48	0.45	1.07	0.81	0.69
Na2O	3.32	5.04	3.87	3.58	3.31	3.78
K2O	0.47	0.49	0.34	0.54	0.56	0.66
TiO2	0.05	0.06	0.08	0.05	0.05	0.06
P2O5	0.05	0.04	0.05	0.04	0.05	0.05
MnO	0.01	0.02	0.01	0.01	0.01	0.02
CO2	0.24	0.23	0.11	0.13	0.21	0.10
S	0.02	0.06	0.06	0.02	0.01	0.06
H2O+	0.22	0.26	0.22	0.25	0.27	0.24
H2O-	0.02	0.01	0.02	0.02	0.02	0.03
LOI	0.40	0.30	0.10	0.20	0.50	0.20
TOTAL	100.10	99.80	99.80	99.30	99.50	100.10

TRACE ELEMENT LISTING

METHOD 82RPS-0025 82RPS-0026 82RPS-0027 82RPS-0028 82RPS-0029 82RPS-0030

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	2.5M	10 M	3.5M	1 M	3.5M	2.5M
Au	AA	-2 B	-2 B	-2 B	-2 B	-2 B	-2 B
Ba	AA	340	370	130	180	300	440
Co	AA	-5	-5	-5	-5	-5	-5
Cr	AA	-5	-5	-5	-5	-5	-5
Cu	AA	-5	6	-5	-5	-5	20
Li	AA	-3	-3	3	4	3	-3
Ni	AA	-5	-5	-5	-5	-5	-5
Pb	AA	275	740	250	42	330	110
Sb	AA	50.1M	113 M	43.8M	19.1M	37.4M	19.1M
Zn	AA	18	31	20	17	13	20
Be	ICP/OES	1	1	-1	1	1	1
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sc	ICP/OES	2	2	1	2	3	2
Sr	ICP/OES	115	185	160	205	190	140
V	ICP/OES	1	1	2	-1	-1	-1
Y	ICP/OES	11	19	14	19	30	19
Ga	XRF	5	6	5	6	6	7
Nb	XRF	9	11	7	11	10	10
Rb	XRF	17	14	11	14	15	10
Zr	XRF	45	65	55	55	60	55
Ce	ICP-MS	35	110	85	45	85	85
La	ICP-MS	-30	-30	-30	-30	-30	-30
Nd	ICP-MS	25	25	25	30	30	30

MAJOR OXIDE LISTING

82RPS-0031 82RPS-0032 82RPS-0033 82RPS-0034 82RPS-0035 82RPS-0036

SiO2	80.90	84.20	87.00	85.10	81.40	81.70
Al2O3	11.30	9.69	8.24	8.82	11.30	11.20
Fe2O3	00.00	00.00	00.00	00.00	00.00	00.00
FeO	0.34	0.21	0.14	0.21	0.55	0.21
MgO	0.46	0.15	0.07	0.12	0.07	0.12
CaO	0.50	0.78	0.28	0.58	0.46	1.09
Na2O	5.22	3.49	3.09	2.43	4.15	4.04
K2O	0.48	0.77	0.35	2.20	1.93	0.57
TiO2	0.05	0.04	0.08	0.04	0.08	0.06
P2O5	0.05	0.05	0.05	0.05	0.04	0.05
MnO	0.01	0.01	0.01	0.05	0.01	0.01
CO2	0.23	0.37	0.09	0.27	0.08	0.39
S	0.06	0.01	0.01	0.01	0.07	0.03
H2O+	0.28	0.27	0.22	0.23	0.18	0.26
H2O-	0.01	0.02	0.02	0.01	0.02	0.02
LOI	0.40	0.60	0.20	0.20	0.30	1.00
TOTAL	99.90	100.40	99.70	100.10	100.30	99.80

TRACE ELEMENT LISTING

METHOD 82RPS-0031 82RPS-0032 82RPS-0033 82RPS-0034 82RPS-0035 82RPS-0036

Ag	AA	-2	-2	-2	-2	-2	-2
As	AA	2 M	-1 M	1.5M	2 M	1 M	1 M
Au	AA	-2 B	5 B	-3 B	2 B	-2 B	-2 B
Ba	AA	140	220	640	430	660	160
Co	AA	5	-5	-5	-5	-5	-5
Cr	AA	22	-5	-5	-5	-5	-5
Cu	AA	8	-5	-5	-5	8	-5
Li	AA	-3	4	-3	-3	-3	-3
Ni	AA	10	-5	-5	-5	-5	-5
Pb	AA	90	-10	31	108	20	60
Sb	AA	18.4M	0.2M	1.8M	12 M	2.4M	3.1M
Zn	AA	12	23	7	15	25	20
Be	ICP/OES	1	-1	-1	1	1	1
Mo	ICP/OES	-10	-10	-10	-10	-10	-10
Sc	ICP/OES	2	2	1	2	4	2
Sr	ICP/OES	145	130	110	35	75	335
V	ICP/OES	2	2	-1	1	-1	-1
Y	ICP/OES	14	21	12	25	22	17
Ga	XRF	5	7	3	6	7	7
Nb	XRF	12	9	6	9	9	7
Rb	XRF	14	20	10	37	35	16
Zr	XRF	60	55	60	45	80	70
Ce	ICP-MS	75	60	80	70	135	80
La	ICP-MS	-30	-30	-30	-30	55	-30
Nd	ICP-MS	25	35	40	25	50	35

MAJOR OXIDE LISTING

82RPS-0037 82RPS-0038 82RPS-0039 82RPS-0040 82RPS-0041 82RPS-0042

SiO2	81.30	81.10	82.80	82.20	83.40	79.90
Al2O3	11.90	11.70	10.50	10.50	10.00	11.60
Fe2O3	00.00	00.00	00.00	0.10	00.00	00.00
FeO	0.15	0.34	0.21	0.29	0.27	0.29
MgO	0.17	0.14	0.12	0.20	0.16	0.11
CaO	0.55	0.62	0.68	1.03	0.81	0.26
Na2O	4.20	5.16	4.19	3.56	3.51	3.20
K2O	1.02	0.46	0.44	0.88	0.65	3.59
TiO2	0.06	0.06	0.05	0.07	0.07	0.05
P2O5	0.05	0.05	0.04	0.05	0.05	0.05
MnO	0.01	0.02	0.01	0.02	0.02	0.01
CO2	0.27	0.18	0.26	0.62	0.50	0.17
S	0.01	0.01	0.03	0.06	0.01	0.05
H2O+	0.27	0.20	0.18	0.35	0.26	0.23
H2O-	0.03	0.01	0.02	0.02	0.02	0.01
LOI	0.60	0.00	0.90	0.00	1.00	0.00
TOTAL	100.00	100.00	99.50	100.00	99.70	99.00

TBACE ELEMENT LISTING

EEDHOD	2RPC-007	82RPS-03	2RPC-009	82RPS-040	2BPC-041	82RPS-042
Ag	AA	-2	-2	2	-	-2
As	AA	- M	1 M	6 M	1 M	0.5 M

1M

Au	AA		2	B		-2	B		-2	B		-	B		6	B		-	B
BA	AA		25			100			17			250		20				500	
Co	AA		-5			-			5			-5			15			-5	
Cb	AA		-5			-5			-			15			-			15	
Cu	AA		15			-5			12			7		5				-	
Li	AA					3			3			6						3	
Bi	AA		-5			-			6			-			5			-5	
Pb	AA		30			9			64			0		3				8	
Cb	AA		1.6A			1.4M			9.4M			4.0M		1.9A				0.0M	
Zn	AA		25			9			24			19		23				106	
Be	AC@/OES		1						1			1		1					
Mo	ICP/OES		-10			-10			-1			-0		11				-0	
Sc	AC@/OES		2			3			2					2				2	
Sr	ICP/OES		17!			105			19			200		17				10	
V	AC@/OES		-1			1			-1			2				2			1
Y	ICP/OES		2			7			3			3		15				12	
Ga	XRF		10			11			6			8		6				13	
NB	XRF		1			13			13			8						13	
Rb	HRF		4			1			12			1		7				30	
Zr	XRF		7			45			60			65		60				55	
Ce	ICP-ES		100			7			10			00		00				90	
LA	ICP/MC		5			-30			-30			0		3				-00	
Nd	IC@-MS		0			12			30			35		00				30	

□
□

MAJOR OXIDE LISTING

□	□	2BPS-0438RPS-0 4	□	□	□	□
SiO2	□	84.50	□	84.10	□	
Al2O3	□	12.00	□	9.68	□	
Fe2O3	□	00.00	□	00.00	□	
FeO	□	0.21	□	0.21	□	
MgO	□	0.05	□	0.00	□	
CaO	□	0.8	□	0.97	□	
FaO	□	0.77	□	3.24	□	
K2O	□	0.6	□	1.8	□	
TiO2	□	0.06	□	0.00	□	
P2O5	□	0.00	□	0.05	□	
EnO	□	0.02	□	0.00	□	
CO2	□	0.31	□	0.06	□	0.03 0.00
H2O+	□	0				

X

23 □ 0.11 □
H2G- □. 5 □ 0.04 □
LOI □ □ □ 0

☐ METHOD ☐ 2RPC-00☐ 3 8"RES-004☐ ☐ ☐ ☐ ☐ ☐

[illegible]

[illegible]

MAJOR OXIDE ANALYTICAL

TOTAL NUMBER OF SAMPLES: 6

Al ₂ O ₃	10.5	STD. DEVIATION	SiO ₂	8.86	0.02
Fe ₂ O ₃	0.01		0.03		
FeO	0.2		0.10	MgO	0.04
CaO	0.67		0		0.08

2

BaO	0.00	0.08
K ₂ O	0.86	0.70
SiO ₂	0.60	0.01
P ₂ O ₅	0.00	0.01
CO ₂	0.20	0.17
C	.03	.02
H ₂ O	0.20	0.07
LOI	.03	.02
TOTAL	9.08	0.20

0.02 0.01

□ TRACE ELEMENT CTATASDICS

□ □	NO. OF CAMPLEC	□ □	MEAN	STD. DEVIATION	
□ Ag	□ 6	□ □	□ -.00	□ . 0	
As	□ 26	□ □	□ □.05	□ .	9
□ Au	□ 6	□ □	□ -1.00	□ 2.03	
□ Ba	□ 26	□ □	□ 30#.85	□ 164.#7	
□ CG	□ 26	□ □	□ -.03	□ .2	
□ Cb	□ 26	□ □	□ -3.#1	□ .14	
□ Cu	26		□ -0.04	7. 1	
Li	26		1.#8	□ .66	
□ NA	□ 6	□ □	□ -.00	□ □ 3.58	
□ Pb	26	□ □ □	□ 53.19	□ 7'.14	
□ Sb	□ 6	□ □	□ 20.08	□ □ 30.05	
ZN	□ 6	□ □	□ 20.15	21.03	
□ Be	26	□ □	□ 0.81	□ 0."9	
□ Mo	□ 26	□ □	□ -1. 0	□ □ . 0	
Sc	□ 6	□ □	□ □.15	□ □ .67	
□ Sr	□ 6	□ □	□ 60.00	□ 59.60	
V	□ 6		.06	□ 1.78	
□ Y	□ 6	□ □	□ 16.84	□ □ 0.01	
□ GA	26		6. 6	□ 2."1	
□ Nb	□ 6	□ □	□ 0.50	4.02	
Rb	□ 6	□ □	□ 10.02	□ 0.09	
Zr	□ 6		□ 50.08	□ 10.50	
□ Ce	□ 22		□ 8#.05	□ 27.67	
□ LA	□ 2	□ □	□ -15.01	3 .69	
Nd	□ 22	□ □	□ 3 .11	□ 10.15	

□ □ CAGE □ □ □ □
MICCEL@AFEUC DADA, AREA□I□ □

□ □ □ □

□
□

MAJGR OPIDE□LISTING

□

□ □ 79BPS-□4□2 8!RPS!0#1□ □1RPC-0320□8□RPS%015□ 81BPS-01"3 83R@S0#1□□
SiO2□ □ □ 7".00 □9.60 7□.20□ □ 46.9 □ □ 7□.80 □ □ 75.3 □
Al"O# □ 1□.40 □ !4.20 □ 1#□0 □ 14"6 □ 1".00 □2.90
Fe2O□ □ □ 0.□1 □ □ 3.3 □ □ □.□3 □4

50	□	0.90	0.8'							
FeO		□ □	.□3	□0.20	□ □.10□	□ □5.92	□ □ .!5□	1481		
MgG		□	□.26	6□62	□ 0."1□	6				

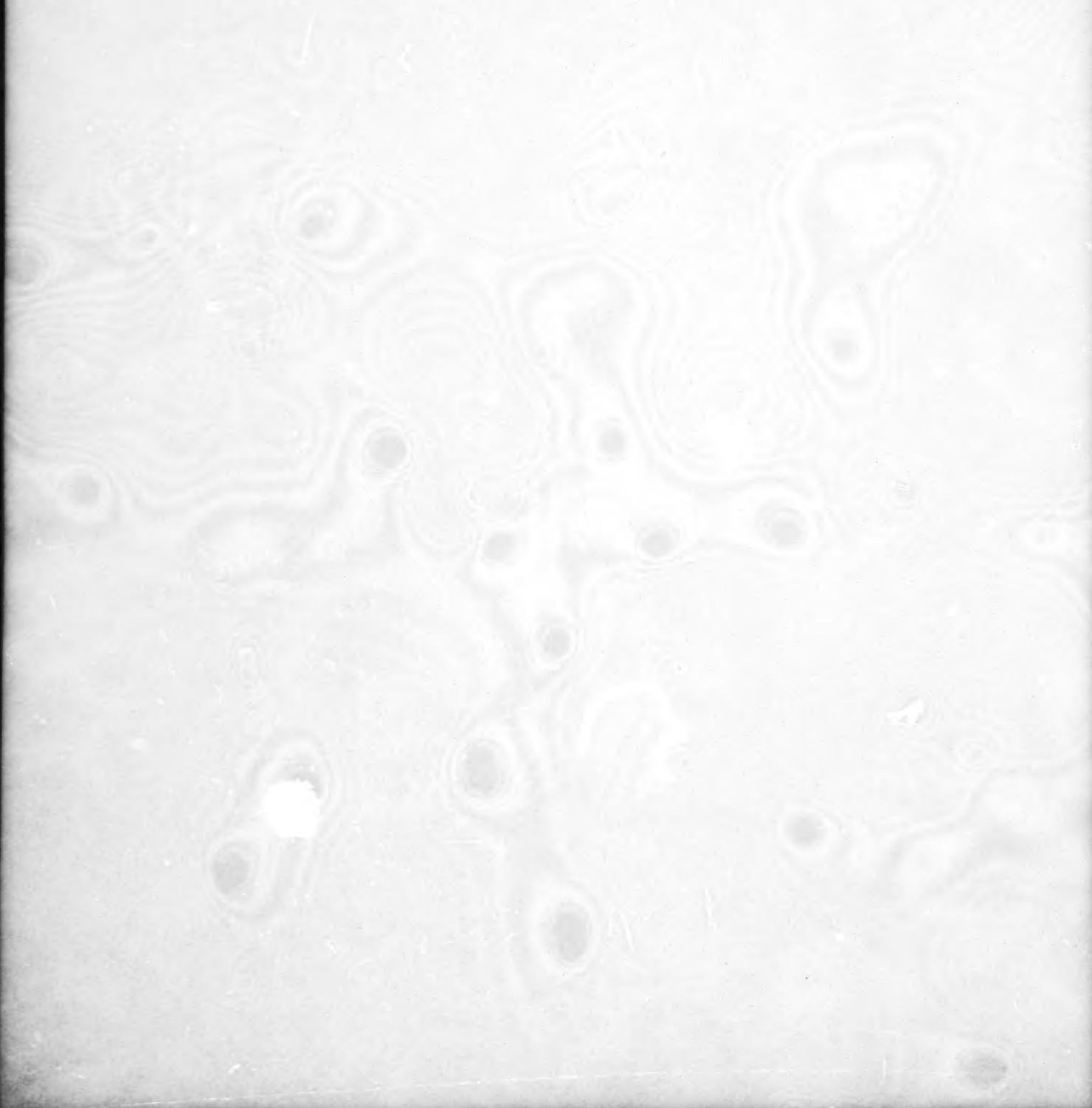
63			.07			00*500	CaO					!.02			5050		1.52
□3.40			!.26			2.87											
Fa20□						00.0			1.48			2.(7			0.9#		0.#3
C2G						3.58			0.00			".(8			000"		3.43
D102□						!.10			1								1617

33 □ □ . \$ 2 □ 0.56 □ 0.15 □ 0051
@205 □ □ □ 00.00 □ 0

0% □

0. 3□

0



1 □ □ 0.□4

0*0□

EnG □ □ □ □ □

0.□4□

□0□2□ □ □ □ .03□ □ □ 0

1□
000

0. 4
□

0.04
□ " . # 7 □

169□

□.17

2

60	□	*.□5	□	□0.2□								
C □ □		□		0.01□ □	□0.2□	□ 0.01	040□	□ 0.02	□	0.0□		
H2G+	□			! .□6 □	48.6□	□ □.75□ □	2.5□ □	□.63		0		

X

66

@20- 0.17 1.00 0.00 0.2 0.07 0.00
 LOI 0.40 5800 0.70 5"2 0.70 1.2
 @O@AD 00 .60 9 500 9).00 19&3 100.10 100.0

□

TRACE ELEMENT LISTING

MET@OD 79RES-6\$4 01BPS-03!4081RES0020 01BPS-01&608RES-0023 83RPS- 3!4

Ag AA -2 12 -" -2 -2 2
 As AA 1 E !.M -1 M 1 M 35 E - M
 AE AA -" B 0 -0 B 7 B -" B 2
 B Ba AA 350 000 910 4 270 0
 Co AA 0 9 0 9 0 -! 0 7
 Cr AA 5 71 5 8 0 -5 0 -
 Cu AA 0 130 0) 104 0 5
 Li AA 10 1 0 9 0 10 0 8 0 1
 Ni AA -8 7 -8 100 0 - 0
 5 Pb AA 0 0 0 4! 0 0 22 27 -
 10
 SB AA 0.8M 0 .M 0 9."M -0.1M
 Rn AA 40 0 3 26 7 26 4
 B ICP/OES 0 0 0 0 0 0 15
 Be ICP/OES 0 ! 1 0 0 1 0
 Mo ICP/OAS -5 0 -0 0 1 0 -0 -10
 Cc ACP/OEC 0 55 6 30 1 0 3
 Sr ICP/OES 23 0 10 6 105 10 260
 V AC@/GEC 10 31! 20 24 0 4 10
 Y ICP/OES 1 18 1' 10 0 2 14
 Ga XRF 11 10 2 1 5 14
 Nb XBF 0 !6 9 12 -1 10
 Rb HRF 0 0 -10 50 1 0 4
 ZB XBF 4 8 135 5 130 2(5
 Sn HRF 0 0 0 0 0 -!
 Ce ICP-MC 130 130 30 1#0 7 100
 La ICP-ES 0 2 0 5 12 52 -#0 75
 Nd ICP/MS 4! 1 41 41 28 0

MAJOB OXADA DISTING

83RES-031# 9BPC-074 8!RES017 (1BPC-121

SiO2			75.8	8.10	57.40	51.90
Al2O3			1.80	6.01	17.00	15.0
Fa2G3			0.72	1.05	4.4	5.13
FeO			1.4	2.5	.83	17.10
MgO			1.00	0.2	0	

29	□ □.16							
CaG	□ □	□.96	□ □2&30	□ 6.09	□	0.6□ □		
Na2C	□	□ 0.74 □	0.18	□	1*9□ □	□.38□		
C2O	□ □	3.04□	□0.00	□.	0	□ □0.00 □		
TaO	□	□0.15 □	0.20	□	0.95 □	! .06 □ □ @2G5□ □	□ □0	
. 0□	00.0 □ □	.09□	□0					

0#

MnO
3. 6

□ □
□ 0

0.10

□

0.10

□

0□29

□ 0. "4□

□ CO□

□ □

TRACE ELEMEND LISTANG
METHOD 8RPS-0#1 9BPC-00#48RPS-017 81RPC-0121

☐ METHOD ☒ RPS-0#1 ☐ 9BPC-00#4 ☐ 8RPS-017 ☐ 81RPC-0121 ☐ ☐ ☐

MAJOR OXIDE STATISTICS

☐ ☐ TOTAL NUMBER OF SAMPLES2 ☐ ☐ 10 ☐

MEAF ☐ STD. DEVIATION
SaO" ☐ 6.8 ☐ 3

71

Al2O3

10.88

□ 2. 6

Fe2O3 □

□2.2□

□

□1

8(

FeO	□ □	4.37	□	8.86			
MgO□	□	2*16	□	(2.4)			
CaO	□	.74	□	3.04			
□NA2G □		1.1	□	1*0)			
C2O		1.00	□	1.55□			
□TaO* □		0.5\$	□	□□4□□□	0205□ □ □	.□4□	□ 0.04□
MfO		0.13	□	□□1 □ □ CO2	□	1.00	□ 1.70□
S□		0					

04 □ □ □ 0.0□□ H2G+
H⁺O- 0

" .07□ □ 14.85

10 □ □ □0.30□ LOA □ (.□9 □ 17.35
TOTAL □1 9

20 □

□283

☐ TBACE EDEMENT STADISTICS

☐	FO. OF	SAMPLES	MEAN	STD& DEFIATAON
Ag	1		2000	0.00
As	1		8	

96 □
□ Au

□3.8\$

□ □140□ □□□ 4

5□

Ba□		10	□ □	□325□00	□	2)4.3"
Co	□	10	□	□5.80	□	"1.96
Cr	□	1	□ □ □ □	#3		

x

30

0104.61

Cu

00

10

0

0 30090

00 \$7

35□ D1
□ □ 49

□1

□

11.70 □

□5.1 □ □ N1□

□ □1□ □

□ 32.70

39□ @b□ 10 □ 31&3□ □ "5.3□
Sb□ 8 □ □ 12&9□ □ □ □ □ 01

300 0 Jn 0 0 01

0 04

60 □ □ □ 49.87

B
□ 0

□ 2

□ □

□ 7.5□

□

45° 9□ □ Be□

(

□ □ □ 1□12

35

Bo □ 10 □ □ □ □ 9.5 □ □ □ 1

5

□ Sc

4

(

□9.25

□

20.17□

Cr□

1□ □

□

93490

□

7!

F □ □1□ □ □ 100.90 □ □ 1#3□40
Y □ 1 □ □ 14.20 □ □ !0*8!□ Ga □1 □ □ 32

60	□	□264□					
□ Fb	□	□	□	11&37 □ □	5.85□ □ Rb	□ □1 □	□ 33.5 □
□8.08□ □ Jr		1□	□	□ 122.3□	□ □ 13.9□		
Cn□ □	□			□0*5 □	2*1□		
Ce□	10	□		1□3*5□ □	□ 32*49		
□ La	□ 10	□ □		□1.80	□ 45.1!		
Fd	□ 10	□ □ □		4*4□	20□98		
□							